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Combat Support Logistics

Sense and Respond Combat Support: Command
and Control-Based Approach
Beyond Authorized Versus Assigned: Aircraft
Personnel Capacity

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Special Feature

The world has changed since the Air Force structured its logistics support organization and processes. In the future, Joint warfighting will place extraordinary demands on the Air Force's ability to execute superior logistics support decisions.

logistics

Combat Support

Sense and Respond Combat Support: Command and Control-Based Approach Beyond Authorized Versus Assigned: Aircraft Maintenance Personnel Capacity

This edition of the Journal presents two featured articles: "Sense and Respond Combat Support: Command and Control-Based Approach" and "Beyond Authorized Versus Assigned: Aircraft Maintenance Personnel Capacity."

In "Sense and Respond Combat Support: Command and Control-Based Approach" the authors examine a new approach to combat support. In the past, prediction and responsiveness have been viewed as competing concepts. The authors argue that both are necessary and can be integrated within a command and control system to create military sense and respond capabilities.

The second featured article examines total not mission capable maintenance (TNMCM) rates for the C-5 fleet. To address the root cause factor of aligning maintenance capacity with demand, a method of determining available maintenance capacity was needed. To meet this need, a new factor designated as net effective personnel (NEP) was developed by the authors. The NEP calculations were ultimately used in conjunction with historical demand to propose base-level maintenance capacity realignments resulting in projected improvements in the C-5 TNMCM rate. This article is the first in a three-part series.



Sense and Respond Combat Support

Command and Control- Based Approach

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This article is dedicated to the memory of Dr C. Robert Roll, a great friend and a scholar.

Nothing is too wonderful to be true.

—Kay Redfield Jamison

Introduction

Modern warfare has evolved from conflicts dominated by massed manpower, the so-called *first generation* of modern (post-Westphalian) war, to a warfare that has integrated political, social, economical, and technological issues. A recent National Defense University study maps this evolution from first generation warfare, culminating in the Napoleonic Wars, to second-generation wars dominated by firepower. Third generation war was the new maneuver tactics developed by the Germans in World War II. Unconventional enemy, in terms of insurgencies and counter-insurgencies, dominates the fourth generation.¹ In fourth generation warfare, the nation-states no longer hold a monopoly on weapon systems and may be involved in long conflicts with stateless enemies. Although insurgency is not new (dating back over two millennium)² the political features of insurgency have become a predominate character of modern insurgents. Advances in information technology also have had a revolutionary impact in these types of warfare.

A constant throughout the history of warfare has been the central role of logistics in the successful prosecution of any conflict. However, the 20th century logistical system lagged behind rapidly changing technology and tremendous efforts were put into the scientific study of logistics. Most of the early supply systems operated on a *push* concept rather than in response to actual needs and changes. It was thought that having an abundance of resources in theater ensured that combat support (CS) elements would be able to provide everything needed to achieve the desired operational effects. In practice, the presence of *mountains of supplies* did not always ensure warfighters' demands were met. In fact, the backlog of war materiel congested the CS system because of inefficiencies in the transportation system and the prioritization processes. It was evident that a more comprehensive capability was needed for matching CS assets to warfighter needs. In the past, prediction and responsiveness have been viewed as competing concepts. However, in this article, we argue that both are necessary and can be integrated within a command and control system to create military sense and respond capabilities.

Military logistics planning grew even more difficult with the collapse of the Soviet Union and the dissolution of the associated threat to United States interests in Europe. The shift in global power exposed the inefficiencies of legacy CS systems that had been hidden under a static and focused, albeit immense, threat. The geopolitical divide that once defined US military policy was replaced by a temporary rise of regional hegemony, which in turn slowly evolved (and continues to evolve) into a geopolitical environment that is defined not only by regional powers, but also by nontraditional security threats. The uncertainty associated with planning for military operations was thus extended to include uncertainty about the *locations* and *purpose* of operations.

**Special
Feature**

Article Highlights

Unless significant improvements are made to last-mile transportation in theater, S&RL will have only a limited effect on operations. A robust, assured transportation network is the foundation on which expeditionary operations, as well as S&RL implementation, rests. The complete integration of transportation into the CSC2 architecture is essential.

Most of the early supply systems operated on a *push* concept rather than in response to actual needs and changes. It was thought that having an abundance of resources in theater ensured that combat support (CS) elements would be able to provide everything needed to achieve the desired operational effects. In practice, the presence of *mountains of supplies* did not always ensure warfighters' demands were met. In fact, the backlog of war materiel congested the CS system because of inefficiencies in the transportation system and the prioritization processes. It was evident that a more comprehensive capability was needed for matching CS assets to warfighter needs. In the past, prediction and responsiveness have been viewed as competing concepts. In "Sense and Respond Combat Support: Command and Control-Based Approach," the authors argue that both are necessary and can be integrated within a command and control system to create military sense and respond capabilities. In the course of the article they outline how this may be accomplished.

The authors conclude by noting that significant challenges remain before the Air Force can realize a sense and respond combat support (S&RCS) capability. To develop effective tools that accurately link logistics levels and rates to

The Air Force, in response to the changing military environment, designed and developed a transformational construct called the Air and Space Expeditionary Force (AEF).³ The implementation of the AEF changed the Air Force's mindset from a threat-based, forward-deployed force designed to fight the Cold War to a primarily continental United States-positioned, rotational, and effects-based force able to rapidly respond to a variety of threats while accommodating a high operations tempo in the face of the uncertainties inherent in today's contingency environment. The AEF prompted a fundamental rethinking and restructuring of logistics. This modern perspective of CS does not merely consider maintenance, supply, and transportation but is expanded to include civil engineering, services (billeting and messing), force protection, basing, and command, control, communications, and computers.

The shift to a more expeditionary force compelled a movement within the Air Force toward a capability called agile combat support (ACS). One of the Air Force's six distinctive capabilities, ACS includes actions taken to create, effectively deploy, and sustain US military power anywhere—at our initiative, speed, and tempo. ACS capabilities include provision for and protection of air and space personnel, assets, and capabilities throughout the full range of military operations.⁴ ACS ensures that responsive expeditionary support for right-sized forces used in Joint operations is achievable within resource constraints. ACS began to emerge as a concept in a series of Air Force and RAND publications,⁵ which detailed both micro- and macro-level analyses. One of the key conclusions of these studies has been the need for a robust and responsive combat support command and control (CSC2) architecture.

Combat Support Command and Control: Key to Agile Combat Support and Essential for Sense and Respond Combat Support

Command and control (C2), although often associated with operations, is also a fundamental requirement for effective CS. As warfighting forces become more flexible in operational tasking, the support system must adapt to become equally flexible. The C2 of modern CS assets must be woven thoroughly with operational events—from planning through deployment, employment, retasking, and reconstitution. Additionally, CS goals and objectives must be increasingly linked directly to operational goals and objectives. The traditional distinction between *operations* and *CS* loses relevance in such an environment. CS activities need to be linked to operational tasking with metrics that have relevance to both warfighter and logistician.

In essence, CSC2 sets a framework for the transformation of traditional logistics support into an ACS capability. CSC2 should provide the capabilities to

- Develop plans that take operational scenarios and requirements, and couple them with the CS process performance and resource levels allocated to plan execution to project operational capabilities. This translation of CS performance into operational capabilities requires modeling technology and predicting CS performance.

Article Highlights

- Establish control parameters for the CS process performance and resource levels that are needed to achieve the required operational capabilities.
- Determine a feasible plan that incorporates CS and operational realities.
- Execute the plan and track performance against calculated control parameters.
- Signal all appropriate echelons and process owners when performance parameters are out of control.
- Facilitate the development of operational or CS get-well plans to get the processes back in control or develop new ones, given the realities of current performances.

CSC2 is not simply an information system. Rather, it sits on top of functional logistics systems and uses information from them to translate CS process performance and resource levels into operational performance metrics. It also uses information from logistics information systems to track the parameters necessary to control performance. It includes the battlespace management process of planning, directing, coordinating, and controlling forces and operations. Command and control involves the integration of the systems, procedures, organizational structures, personnel, equipment, facilities, information, and communications that enable a commander to exercise C2 across the range of military operations.⁶ Previous studies built on this definition of C2 to define CS execution, planning, and control to include the functions of planning, directing, coordinating, and controlling CS resources to meet operational objectives.⁷

The objective of this transformed CSC2 architecture is to integrate operational and CS planning in a closed-loop environment, providing feedback on performance and resources. The new CSC2 components significantly improve planning and control processes, including

- Planning and forecasting (prediction)
 - Joint analysis and planning of CS and operations
 - Determining feasibility, establishing control parameters
- Controlling
 - Monitoring planned versus actual execution—a feedback loop process allowing for tracking, correction, and replanning when parameters are out of control
- Responsiveness
 - Quick pipelines and the ability to respond quickly to change

One of the key elements of planning and execution is the concept of an effective feedback loop that specifies how well the system is expected to perform during planning, and contrasts these expectations with observations of the system performance realized during execution. If actual performance deviates significantly from planned performance, the CSC2 system warns the appropriate CS processes that their performance may jeopardize operational objectives. The system must be able to differentiate small discrepancies that do not warrant C2 notification from substantial ones that might compromise future operations. This requires the identification of *tolerance limits* for all parameters, which is heavily dependent on improved prediction capabilities. This feedback loop process identifies when the CS plan and infrastructure need to be reconfigured to meet dynamic operational requirements and notifies the logistics and installations support planners to take action, during both planning and execution.

operational effects, the modern Expeditionary Combat Support System must be developed and tested in conjunction with operations and intelligence systems.

Technologies associated with S&RL are still in an early stage of development and may not be fielded for a number of years. Ultimately, the Expeditionary Combat Support System should relate how combat support performance and resource levels affect operations, but current theoretical understanding limits these relationships. The Air Force does not appear to be lagging behind industry in the implementation of S&RL capabilities but should continue to make judicious investments in this field.

The Air Force has recently established the Global Logistics Support Center as the single agent responsible for end-to-end supply chain management. The creation of this entity holds promise for the achievement of S&RCS capabilities. The Global Logistics Support Center should be in a position to advocate for future improvements while exploring ways to provide the capability utilizing current systems.

Article Acronyms

ABM – Agent-Based Models
ACS – Agile Combat Support
AEF – Air and Space Expeditionary Force
C2 – Command and Control
CoAX – Coalition Agent Experiment
CS – Combat Support
CSC2 – Combat Support Command and Control
DARPA – Defense Advanced Research Projects Agency
DoD – Department of Defense
ECSS – Expeditionary Combat Support System
IT – Information Technology
OFT – Office of Force Transformation
RFID – Radio Frequency Identification
S&R – Sense and Respond
S&RCS – Sense and Respond Combat Support
S&RL – Sense and Respond Logistics

A robust CSC2 construct will enable a sense and respond capability that integrates operational and CS planning in a closed-loop environment, providing feedback on performance and resources. Figure 1 illustrates this concept in a process template that can be applied through all phases of an operation from readiness, planning, deployment, employment, and sustainment to redeployment and reconstitution.

This comprehensive transformation of CSC2 doctrine and capabilities blends the benefits of continuously updated analytical prediction with the ongoing monitoring of CS systems, which, given a robust transportation capability, enables the rapid response necessary to produce a sense and respond combat support (S&RCS) model appropriate for military operations in the 21st century.

Defining Sense and Respond Combat Support

The emphasis on the ability to *respond* quickly and appropriately through the command and control function to the broader areas constituting CS is how this article differentiates S&RCS from the traditional definition of sense and respond logistics (S&RL). Implementing S&RL concepts and technologies through the CSC2 architecture is the way to achieve an S&RCS capability.

Traditionally, ongoing planning and tasking often occur in isolation from those who would subsequently be required to support the levels and rates of tasking. Coordination, if any, occurs after initial planning cycles are completed. Modern, responsive systems demand information-sharing among all partners in the military enterprise. Moreover, tools and technology play a vital role in this enterprise.

In an often volatile commercial market, the manufacturer and distributor constantly monitor changes in buying patterns and adapt quickly to maintain market share. By employing S&RL, commercial enterprise has been able to reduce investments in warehouses and stock. Industry now increasingly produces what is desired and required rather than what a planner thinks should be built based on internal production goals. Commercial S&RL, in theory, reduces stock and overhead costs and responds rapidly to change.⁸ The key to these improvements is a robust system of information-gathering and analysis or, in military terms, a highly efficient C2 system.

Commercial practices and commercial definitions of S&RL fall short of what is needed to create S&RCS in the Air Force environment. Although there are similarities between some of the issues and constraints of the military and those of a large corporation, the risk of human casualty, the consequences to the international political order, and vastly different military objectives set the Department of Defense (DoD) apart from any corporation of comparable size. The scope of activities included in military CS is also much broader than that of commercial

logistics; any reorganizational concept must consider the nuances of military operations. It is interesting to note that firms have designed lean supply chains to be resilient to business disruptions,⁹ but it has been shown that resiliency for firms may not translate to resiliency for the entire supply chain and the government provision of pliability and redundancy may be necessary in an era of lean supply chain management.¹⁰ In the military case, the Air Force is the sole user and provider and thus the business notions of resiliency may not be entirely applicable.

Traditionally, ongoing planning and tasking often occur in isolation from those who would subsequently be required to support the levels and rates of tasking. Coordination, if any, occurs after initial planning cycles are completed. Modern, responsive systems demand information-sharing among all partners in the military enterprise. Moreover, tools and technology play a vital role in this enterprise.

A Brief Survey of Sense and Respond Tools and Technology

The DoD Office of Force Transformation (OFT) developed the military sense and respond logistics concept, borrowing heavily from research in the commercial sector (which was in turn

indebted to earlier military efforts, such as the observe, orient, decide, and act loop)¹¹ to describe an adaptive method for maintaining operational availability of units by managing their end-to-end support network. OFT addresses S&RL from a Joint force perspective and as an important component of DoD's focused logistics strategy.

OFT considered architectural development planning that includes the development of an information technology S&RL prototype. One of these architectural concepts is the Integrated Enterprise Domain Architecture, which has the objectives of integrating, accommodating, and employing concepts and components of logistics, operations, and intelligence architectures and of their command, control, communications, computers, intelligence, surveillance, and reconnaissance concepts.¹² Presently, Integrated Enterprise Domain Architecture is in a predevelopment stage, but plans are to eventually link it to other architectures or programs, including Joint Staff J4, Joint Forces Command, US Marine Corps, United States Transportation Command, and possibly certain organizations in the Navy and the Army. Among the in-work project linkages is

the RAND-Air Force CSC2 Operational Architecture as the Air Force vehicle for coordinating with concepts in S&RL.

Overall, the OFT program for S&RL is in a very early stage, but it has the potential to influence and effect near- to mid-term changes in some current programs using S&RL technologies. OFT suggests that elements of the concept can be employed in an evolutionary development in the very near term and could result in immediate operational gains.¹³ OFT has also identified a number of technologies that are essential in an S&RL system, two of which were highlighted as especially important components: radio frequency identification and intelligent (adaptive) software agents.

However, before we discuss these components it is noteworthy to present some of the technical requirements that are essential in supporting sense and respond CS. Although there is great diversity amongst various approaches to sense and respond logistics implementation and its applications, a general theme is best stated by the IBM Sense and Respond Enterprise Team.¹⁴ These criteria are in line with RAND's CSC2 concepts which the Air Force is in the process of implementing.¹⁵ In general, technologies and innovation to support sense and respond (S&R) must have the following:

- The ability to detect, organize, and analyze pertinent information and sense critical business (force) conditions
- The filters for enterprise data to enable stable responses to disturbances in the business or military environment
- The intelligent response agents that analyze global value chain relationships and information and derive the optimal strategy for the best supply chain performance
- Predictive modeling at multiple levels: strategic, tactical, and operational

- Agent coordination mechanisms at multiple levels: strategic, tactical, and operational
- The ability to learn by comparing previously predicted trends with recorded data and information to improve future responses
- A software infrastructure to integrate heterogeneous and collaborative agents implementing critical business policies and making operational decisions

This concept can be contrasted with the OFT perspective. OFT, within its All Views Architecture, lists specific systems architecture components for S&RL, including the following capabilities:¹⁶

- Passive and active tagging, instruments, and sensors that provide location status, diagnoses, prognoses, and other information relative to operations space entities, especially for conditions and behavior that affect force capabilities management, logistics, and sustainment.
- Intelligent software agents that represent operations space entities, conditions, and behaviors, provide a focus for control of action or behavior, or act as monitors.
- S&RL knowledge bases oriented toward force capabilities management, logistics, and sustainment.
- S&RL reference data, again focused on force capabilities, assets, and resources related to force capabilities management, logistics, and sustainment.
- S&RL rule sets, which govern the operations and organization of S&RL functions, activities, and transactions.
- S&RL cognitive decision support tools uniquely supporting force capabilities management, logistics, and sustainment.
- Unique S&RL processes, applications, portals, and interfaces not provided either by Distributed Adaptive Operations

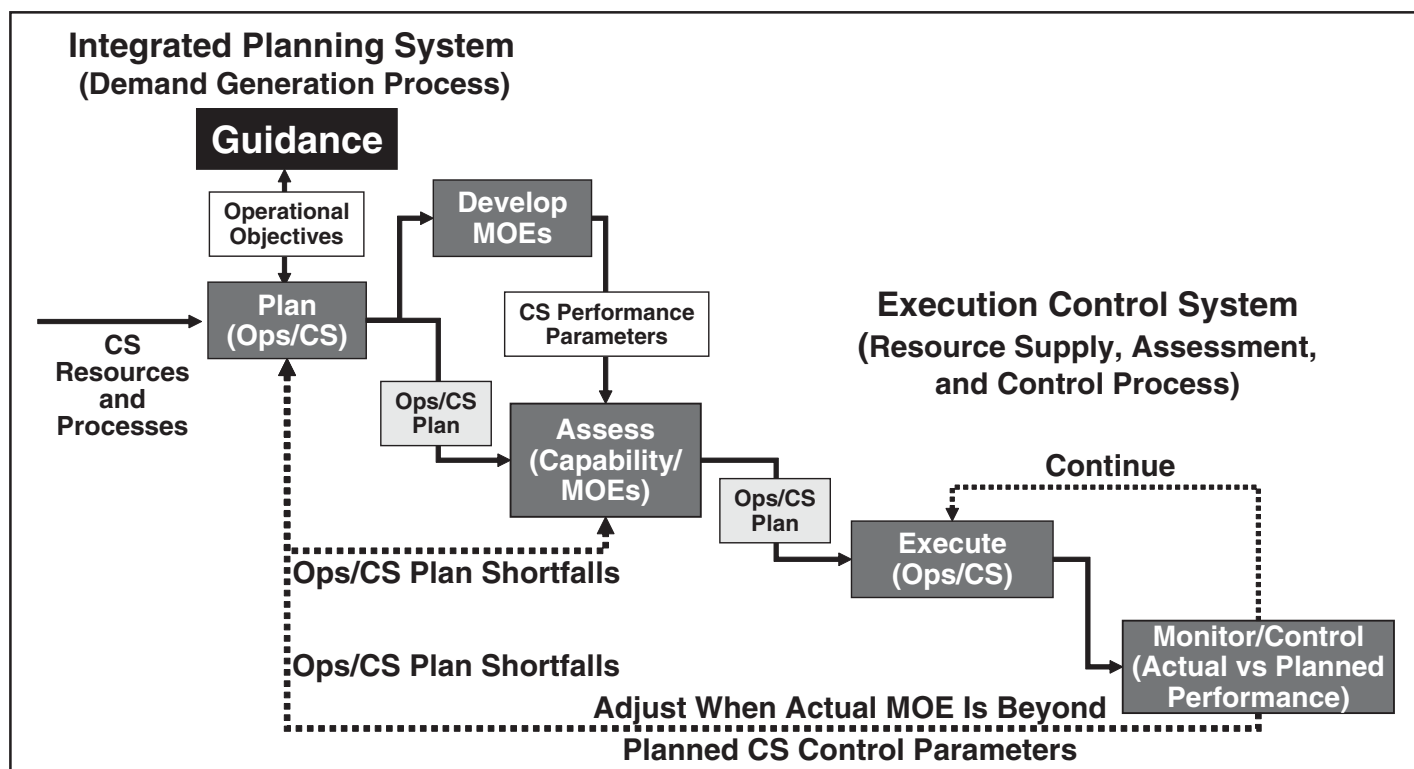


Figure 1. Feedback Loop Process

Command and Control or the Network-Centric Operations and Warfare infrastructure.

These are representative of the technologies and innovations that have been identified with military and commercial S&RL initiatives. In the next section, we discuss two important technologies needed to enable an ultimate S&RCS capability: radio frequency identification (RFID) and intelligent (adaptive) software agents.¹⁷

Radio Frequency Identification. RFID is an automatic identification technology that provides location and status information for items in the CS system. RFID technologies are fairly mature and have been fielded in both commercial and military arenas. Technically, RFID offers a way to identify unique items using radio waves. Typically, a reader communicates with a tag, which holds digital information in a microchip. However, some chipless forms of RFID tags use material to reflect back a portion of the radio waves beamed at them. This technology is of equal interest to military and commercial enterprises.

There are several examples of real-time information-gathering and distribution. For example, in Iraq, some Marine units had active tags not just on pallets but also on vehicles. RFID readers were set up at a distribution center in Kuwait, at the Iraq-Kuwait border, and at checkpoints along the main arteries in Iraq. When trucks passed the readers, the location of the goods they were carrying was updated in the DoD's in-transit visibility network database. This enabled commanders on the ground to see the precise location of the replenishments needed to sustain operations. RFID implementation is limited, but the DoD goal is to minimize human involvement when collecting data on shipments and their movements.

The Application of Agent Technology. The application of agent technology in S&RL research has become pervasive both in military and nonmilitary programs. Agent-based modeling (ABM) allows a more robust simulation of CS operations.¹⁸ Agent-based models are already in wide use within the DoD for force-on-force simulations but have only recently been adapted for military logistics use. The logistics domain is distributed and involves decentralized (autonomous) organizations. These organizations are also

- Intentional entities, with goals, functions, roles, and beliefs, using processes and expertise to achieve their goals
- Reactive, and thus responsive to changes that occur in their environment
- Social, so they interact with other organizations to achieve their goals, where the social interaction is typically complex, such as negotiation, rather than just action requests

The similarity in characteristics between agents and organizations makes agents an appropriate choice for modeling organizations. This also explains agent functionality in carrying out organizational or human processes in S&RL applications. Moreover, robust distributed C2 strategies can also be tested using ABMs.¹⁹ Although some simple supply chain simulations have been done for logistics, almost none have modeled actual organizations with the requisite detail and calibration necessary to compare alternative policies and gain insight.

Although individual automated software agents are already employed commercially for particular tasks, intelligent multi-

agent systems are still in early development.²⁰ Consequently, ABMs have only had a limited effect on practical decisionmaking. Only in recent years have academic researchers explored the use of intelligent agents for supply chain management.²¹ Although ABMs are properly understood as multi-agent systems, not all agents or multi-agent systems are employed for modeling and simulation purposes. Several researchers, including some under DoD contracts, have developed applications of ABMs for supply chain management.²²

Agents have been used in telecommunications, e-commerce, transportation, electric power networks, and manufacturing processes. Within telecommunications, software agents bear the responsibility for error-checking (such as dropped packets), routing and retransmission, and load-balancing over the network. Web-search robots are agents that traverse Web sites collecting information and cataloging their results. When a customer searches for an item on a Web site, say Amazon.com, at the bottom of the page there is a list of similar products that other customers interested in the item also viewed. Similar agents assemble customized news reports and filter spam from e-mail. Data-mining agents seek trends and patterns in an abundance of information from varying sources and are of particular interest for all-source intelligence analysis.²³

A World of Initiatives

The following discussion represents recent and current initiatives, both public and private, to develop sense and respond capabilities.

- The Defense Advanced Research Projects Agency (DARPA) has been working on an end-to-end logistics system under the Advanced Logistics Project.²⁴ Under this project, DARPA developed an advanced agent architecture with applications to logistics. As follow-on to Advanced Logistics Project, DARPA initiated a program called Ultra-Log that attempted to introduce robust, secure, and scalable logistics agents into the architecture. Ultimately, ultra-Log is seeking valid applications to DoD problems (such as Defense Logistics Institute applications) while adopting commercial open-source models.
- DARPA led another experiment called Coalition Agent eXperiment (CoAX), which was an example of the utility of agent technology for military logistics planning. A multi-agent logistics tool, implemented within CoAX, was developed using agent technology to have agents represent organizations within the logistics domain and model their logistics functions, processes, expertise, and interactions with other organizations. The project generated important lessons for S&RL, identifying two types of issues that need to be overcome for agents to be effectively used for military logistics planning—technological and social (human acceptability). RAND believes the issues are the same for use in executing logistics functions. Under technology, the identified issues include logistics business process modeling, protocols, ontologies, automated information-gathering, and security. We found some of these being addressed in DARPA's work. Under social acceptability, the following were important: trusting agents to do business for you, accountability and the law, humans and agents working together, efficiency metrics, ease of use, adjustable autonomy, adjustable visibility, and social acceptability versus optimality.

- The Air Force Research Laboratory, Logistics Readiness Branch (AFRL/HEAL) has focused its attention on human factor issues in S&RL, with a concentration on cognitive decision support.²⁵ AFRL proposes to focus on the human aspects of distributed operations by researching and developing enhanced or novel methodologies and measures to evaluate the effect of collaboration technologies on human performance from an individual, team, and organizational perspective. This group suggests that human performance metrics should be created along with other performance metrics for S&RL functions and activities in the military enterprise, although such considerations are currently not being called for in the requirements.

In addition to the multiple DoD-led initiatives, a number of commercial sector and university initiatives have developed some of the technologies needed to enable an S&RCS capability and presents a number of industrial applications of fielded S&R systems. These included an IBM Sense and Respond Blue program, which was a major influence on the military OFT enterprise definition and emphasized the employment of careful planning as well as intelligence, flexibility, and responsiveness in execution in order to achieve high levels of distributed efficiency.²⁶ In addition, General Electric Transportation Systems

technology prototyping for CSC2 because it should drive information technology investments among S&RL technologies.

Air Force Combat Support Command and Control Implementation Effort

The Air Force has taken initial steps to implement the CS command and control operational architecture. Its efforts are designed to help enable AEF operational goals. Implementation actions to date include changes in C2 doctrine, organizations, processes, and training. Although progress has been steady, the area of information systems and technology requires increasing application of modern capabilities. The emerging modernized logistics information systems emphasize mostly business process improvements, with little focus on CS challenges and requirements. Additionally, CS systems are not being coordinated and tested in an integrated way with operations and intelligence systems. The architecture and requirements for peacetime and wartime logistics and CS information systems will need to be more closely coordinated.

The Air Force has begun evaluating the effectiveness of CSC2 concepts in exercises. Improving CSC2 organizations, processes, and information systems hardware, software, and architecture

Although individual automated software agents are already employed commercially for particular tasks, intelligent multi-agent systems are still in early development.²⁰ Consequently, ABMs have historically only had a limited effect on practical decisionmaking. Only in recent years have academic researchers explored the use of intelligent agents for supply chain management.

developed and fielded an autonomic logistics capability for its locomotive engine business. This capability is enabled through an onboard computing and communications unit that hosts software applications, continuously monitors locomotive parameters, and provides communications to General Electric's Monitoring and Diagnostics Service Center.²⁷

Based on this technology review of both military and commercial activities and initiatives (and a more thorough review detailed in the RAND monograph²⁸), we concluded that although current technology has enabled a limited set of sense and respond capabilities, a full implementation of S&RL concepts remains dependent on substantial future technological development. The largest challenge ahead for implementing a broader S&RCS capability is the development of an understanding of the interactions between CS system performance and combat operational metrics. Without the proper metrics for measuring the agent (and other) technologies used in S&RCS implementation, it is difficult to project where or when CSC2 effectiveness best stands to gain from this technology insertion. This is an important subject to address through information

will require several years of active involvement by US Air Force Headquarters as well as Air Force initiatives to restructure a system that was previously organized around fixed-base, fight-in-place air assets. However, there are active efforts to structure CSC2 activity and policy in a way that should effectively support forces throughout the 21st century. Below is a summary of the status of Air Force implementation actions.

C2 Doctrine. The Air Force initiated a review of its doctrine and policy and began revisions to reflect the robust AEF CSC2 operational architecture. Such actual and planned changes to Air Force doctrine and policy are on the right track. As doctrine is changed, procedures, policies, organizations, and systems can then be changed to align with the changing concepts of warfare. Perhaps the most significant opportunity for improvement is the integration of CS and operational planning. Currently, there are no standard processes for operational planners to communicate operational parameters to CS planners. This deficiency greatly hinders timely, accurate CS planning. Creating a framework, reinforced in doctrine, to delineate specifically what information operations planners provide, in what format, and to whom could

address this shortfall. Solidifying this linkage between operations and logistics in crisis action planning would enable a step forward in the coordination, timeliness, and accuracy of CS planning.

Organizations and Processes. The Air Force has made progress in establishing standing CS organizations with clear C2 responsibilities and developing processes and procedures for centralized management of CS support resources and capabilities.

Training. The Air Force has made much progress in improving CSC2 training, including the formation of an education working group, to address the development and enhancement of formal education programs. The group will also address the implementation of significant new C2 instruction at the Air Force Advanced Maintenance and Munitions Officers School at Nellis Air Force Base, Nevada,²⁹ and the development of the Support Group Commanders Course and the new CS Executive Warrior Program, which will provide training for support group commanders, who are potential expeditionary support group commanders and A4s.

Information Systems. This area needs the most change. These changes should include the following:

- Relate operational plans to CS requirements

Significant challenges remain before the Air Force can realize an S&RCS capability. To develop effective tools that accurately link logistics levels and rates to operational effects, the modern Expeditionary Combat Support System must be developed and tested in conjunction with operations and intelligence systems. Only through integrated testing can the CSC2 architecture be properly developed and implemented.

- Convert CS resource levels to operational capabilities
- Conduct capability assessments and aggregate on a theater or global scale
- Conduct tradeoff analyses of operational, support, and strategy options
- Focus integration efforts on global implementation of a few selected tools
- Standardize tools and systems for consistent integration

Most of the logistics information systems' modernization efforts are linked to improving information technology solutions, which support day-to-day business processes. Modernization of the peacetime systems will certainly yield some improved CSC2 information ability. However, the requirements for a more robust S&RCS capability need to be considered within the wartime CSC2 architecture. CS system modernization will need to assess both peacetime and deployment requirements and produce tools and capabilities that will satisfy business processes as well as CSC2 needs.

Enterprise-Wide Systems and Combat Support Command and Control. CSC2 analytical and presentation tools will need to augment typical data processing with increasingly modern sense and respond capabilities. Batch processing and analysis, a proven rate and methodology for most of the Air Force's 60 years of experience, will not effectively support agile combat operations and effects-based metrics. To respond to continuously changing desired effects, enemy actions, rates of consumption, and other controlling inputs, the 21st century logistics warfighter will need to accumulate, correlate, and display information rapidly and in graphic formats that will be equally understandable for operators and logisticians. Data will need to be refreshed much more rapidly than the former monthly and quarterly cycles. Daily decisions will require daily (if not hourly or possibly continuous) data refresh cycles.

A closed-loop planning and control system is essential to a robust military S&RCS architecture. Currently, information about Air Force resource and process metrics is organized by commodity or end item and located on disparate information systems. Creating a single system accessible to a wide audience would enhance leadership visibility over these resources. Such a system needs to have enough automation to translate lower-level process and data into aggregated metrics, which can be related in most cases to operational requirements.

The greatest change required in modernized logistics systems is to reorient existing logistics systems toward combat-oriented ones. The peacetime-only materiel management systems need to be structured to participate in the enterprise-wide sharing of data and culling of information.

Stand-alone, single-function systems need to be replaced with systems that serve several functions for CS leaders at all echelons. Finally, modern CSC2 systems need to provide information useful in both peacetime and wartime decisionmaking.

Future Work and Challenges

The Air Force has made some progress toward implementing doctrine and policy changes, and plans are in place to continue to close the information technology and analytical tools gaps. An expanded Air Force *to-be* CSC2 execution planning and control architecture system would enable the Air Force to meet its AEF operational goals. New capabilities include the following:

- Enable the CS community to quickly estimate support requirements for force package options and assess the feasibility of operational and support plans
- Facilitate quick determination of beddown needs and capabilities
- Ensure rapid time-phased force and deployment data development
- Support development and configuration of theater distribution networks to meet Air Force employment timelines and resupply needs
- Facilitate the development of resupply plans and monitor performance
- Determine the effects of allocating scarce resources to various combatant commanders
- Indicate when CS performance begins to deviate from desired states and facilitate development and implementation of get-well plans

CS and operations activities must be continuously monitored for changes in performance and regulated to keep within planned objectives. Significant advances must be made in the way planning, directing, coordinating, and controlling functions are performed to move the Air Force toward a robust S&RCS capability. These essential elements of an effective C2 system must be altered to allow them to accomplish the important aspects of sensing and responding to changes in operating parameters when the violation of tolerance becomes evident. These sense and respond activities will need to take place in a nearly real-time environment.

The objective of rapid sensing and response is to alert decisionmakers to initial deviations in the plan, rather than reacting after-the-fact, to situations affecting mission capability. Emphases of metrics in the future need to be on *outcomes*, rather than on *outputs*. The RAND report details necessary adaptations that include (at the minimum) the following improvements in CSC2 architecture and activities.

- **Planning.** With the AEF's short timelines and pipelines, it is critical to be able to add CS information to initial planning, giving planners flexibility and confidence. CS execution planning functions include monitoring theater and global CS resource levels and process performance, estimating resource needs for a dynamic and changing campaign, and assessing plan feasibility. Because capabilities and requirements are constantly changing, these activities must be performed continuously so that accurate data are available for courses of action and ongoing ad hoc operational planning.
- **Directing.** CS-directing activities include configuring and tailoring the CS network, and establishing process performance parameters and resource thresholds.³⁰ Planning output drives infrastructure configuration direction—there must be an ongoing awareness of CS infrastructure and transportation capabilities to feed into operational planning and execution. Once combat operations commence, the logistics and installations support infrastructure must be regulated to ensure continued support for dynamic operations. The system must monitor actual CS performance against the plan. The performance parameters and resource buffers established during execution planning will provide advance warning of potential system failure.

- **Coordinating.** Coordination ensures a common operating picture for CS personnel. It includes beddown site status, weapon system availability, sortie production capabilities, and other similar functions. Coordination activities should be geared to providing information to higher headquarters to create an advance awareness of issues should one be needed at a later date. Great effort must be made to effectively filter the information flows up the command chain, to avoid overwhelming commanders with information of little utility, but to provide sufficient information to improve battlespace awareness.
- **Controlling.** During the execution of peacetime and contingency operations, CS control tracks CS activities, resource inventories, and process performance worldwide, assessing root causes when performance deteriorates, deviates from what is expected, or otherwise falls out of control. Control modifies the CS infrastructure to return CS performance to the desired state. CS control should evaluate the feasibility of proposed modifications before they are implemented and then direct the appropriate organizations to implement the changes.

Toward a Responsive System

The Air Force has already begun to take steps to implement some of these concepts and technologies with varying degrees of success. Air Force implementation actions include making doctrine changes to recognize the importance of CSC2, as part of S&RCS capabilities, and identifying training and information system improvements.

However, significant challenges remain before the Air Force can realize an S&RCS capability. To develop effective tools that accurately link logistics levels and rates to operational effects, the modern Expeditionary Combat Support System (ECSS) must be developed and tested in conjunction with operations and intelligence systems. Only through integrated testing can the CSC2 architecture be properly developed and implemented.

Technologies associated with S&RL are still in an early stage of development and may not be fielded for a number of years. Ultimately, ECSS should relate how CS performance and resource levels affect operations, but current theoretical understanding limits these relationships. The Air Force does not appear to be lagging behind industry in the implementation of S&RL capabilities but should continue to make judicious investments in this field.

The Air Force has recently established the Global Logistics Support Center (GLSC) as the single agent responsible for end-to-end supply chain management. The creation of this entity holds promise for the achievement of S&RCS capabilities. The GLSC should be in a position to advocate for future improvements while exploring ways to provide the capability utilizing current systems.

Finally, the observations of the Joint Logistics Transformation Forum are worth repeating: Unless significant improvements are made to *last-mile* transportation in theater, S&RL will have only a limited effect on operations. A robust, assured transportation network is the foundation on which expeditionary operations, as well as S&RL implementation, rests. The complete integration of transportation into the CSC2 architecture is essential.

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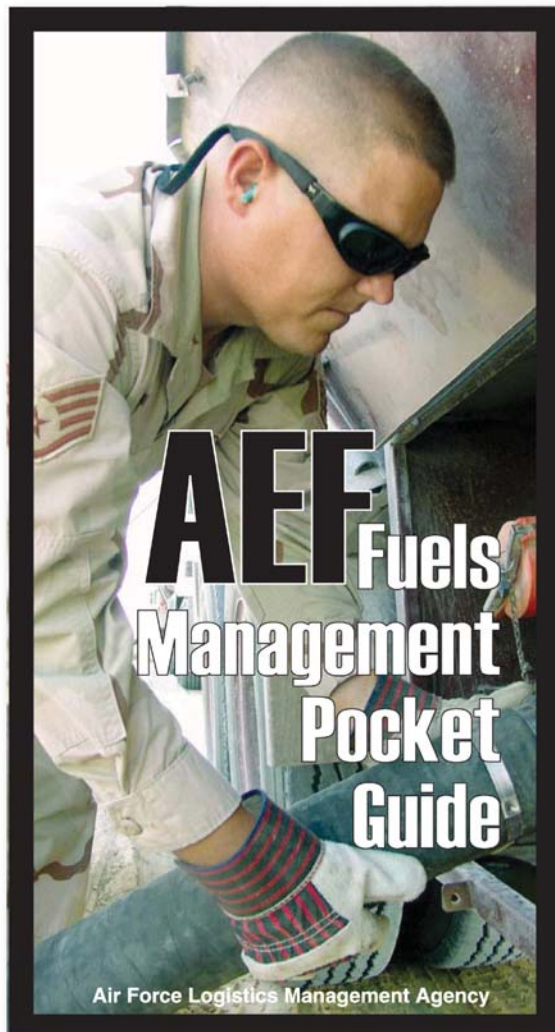
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Introduction

Most would agree that aircraft maintenance has been and continues to be a challenging, complex task involving a delicate balance of resources to include personnel, equipment, and facilities. This balancing act occurs in a very

Special Feature

hectic environment. The Air Force flies 430 sorties per day in support of Operation Iraqi Freedom and Enduring Freedom. A mobility aircraft takes off somewhere in world approximately every 90 seconds.¹ As the demand for aircraft continues to grow, the number of airmen who

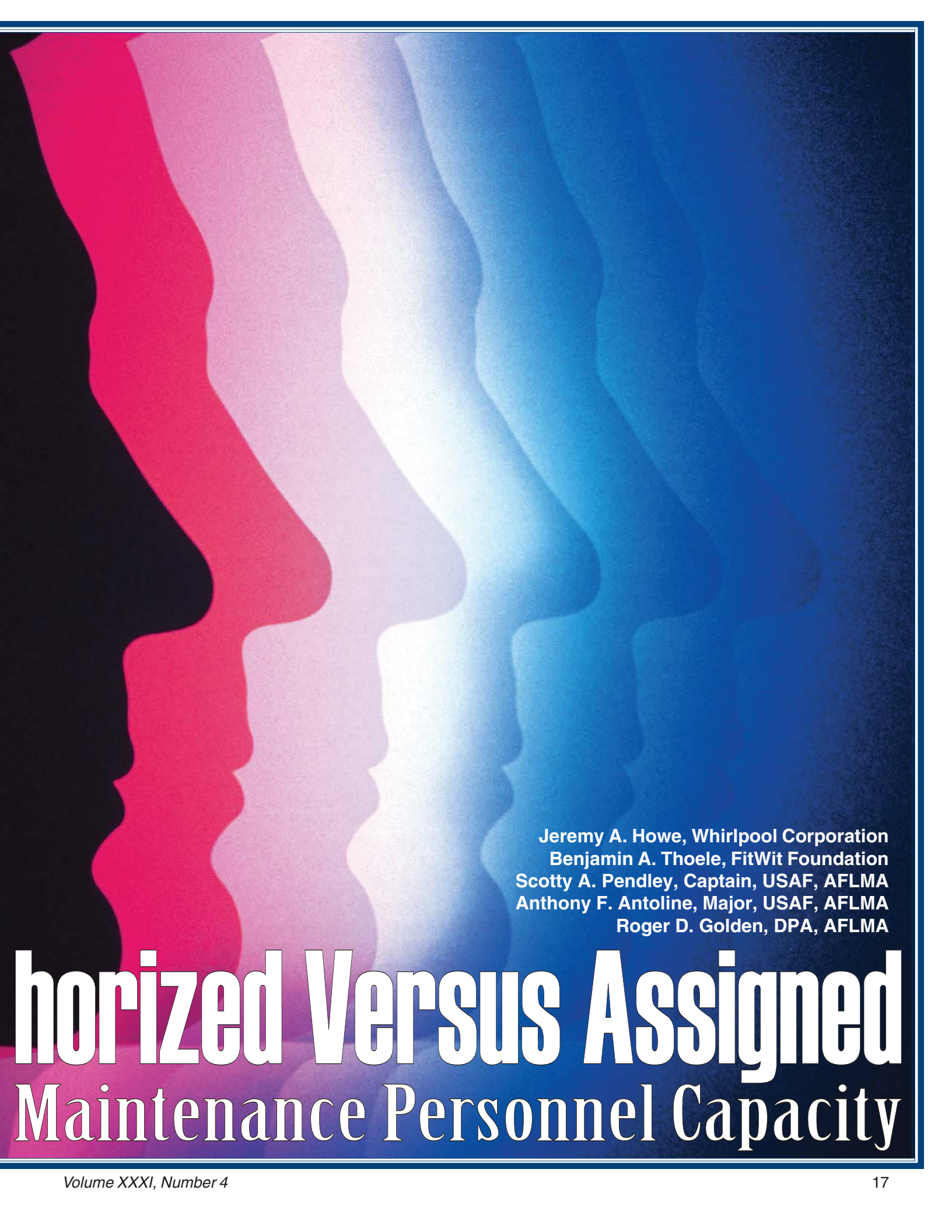
support these aircraft is declining. "Since 2001 the active duty Air Force has reduced its end-strength by almost 6 percent but our deployments have increased by at least 30 percent, primarily in support of the Global War on Terror."² This reduction in personnel is part of the Air Force's process of drawing down the total force by approximately 40,000 people, with many of these cuts in aircraft maintenance career fields. Also adding to the growing maintenance workload is an aircraft fleet which now averages almost 24 years old, with the average age still increasing.³

When it comes to aircraft maintenance, the Air Force depends on metrics to know whether or not we are measuring up to standards. Several metrics exist which attempt to measure the success or failure of our maintainers' efforts. One of the most recognized metrics is the total not mission capable maintenance (TNMCM) rate. Air Force Instruction 21-101 describes TNMCM as "perhaps the most common and useful metric for determining if maintenance is being performed quickly and accurately."⁴ Although a lagging type indicator, it is one of several key metrics followed closely at multiple levels of the Air Force. Over the last several years, the TNMCM rate for many aircraft gradually increased. This fact was highlighted during a 2006 quarterly Chief of Staff of the Air Force Health of the Fleet review. Follow-on discussions ultimately resulted in the Air Force Materiel Command Director of Logistics (AFMC/A4) requesting the Air Force Logistics Management Agency (AFLMA) to conduct an analysis of TNMCM performance with the C-5 Galaxy aircraft as the focus. AFLMA conducted two studies in support of this request.

Background

The *C-5 TNMCM Study II* (AFLMA project number LM200625500) included five objectives. One of those objectives was to determine root causes of increasing TNMCM rates for the C-5 fleet. An extensive, repeatable methodology was developed and utilized to scope an original list of 184 factors down to two potential root causes to analyze in-depth for that particular study. These two factors were aligning maintenance capacity with demand, and the logistics departure reliability versus TNMCM paradigm. To address the root cause factor of aligning maintenance capacity with demand, a method of determining available maintenance capacity was needed. To meet this objective, a new factor designated as net effective personnel (NEP) was developed. NEP articulates available maintenance capacity in a more detailed manner that goes

Beyond Aut Aircraft



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horized Versus Assigned Maintenance Personnel Capacity

Article Highlights

Ultimately, the NEP methodology has the potential to be used alone or in conjunction with the Logistics Composite Model to better portray maintenance personnel requirements and capabilities based on experience and skill levels.

“Beyond Authorized Versus Assigned: Aircraft Maintenance Personnel Capacity” quantifies the phrase “we need more people” beyond the traditional metric of authorized versus assigned personnel. The article is based on work done for a recent Air Force Logistics Management Agency project—*C-5 TNMCM Study II*. During this project, an extensive, repeatable methodology was developed and utilized to scope an original list of 184 factors down to two potential root causes. These two factors were aligning maintenance capacity with demand, and the logistics departure reliability versus TNMCM paradigm. To address the root cause factor of aligning maintenance capacity with demand, a method of determining available maintenance capacity was needed. To meet this need, a new factor designated as net effective personnel (NEP) was developed. NEP articulates available maintenance capacity in a more detailed manner that goes beyond the traditional authorized versus assigned viewpoint. The article describes how the NEP calculations were developed during the *C-5 TNMCM Study II*. The NEP calculations were ultimately used in conjunction with historical demand to propose base-level maintenance capacity realignments resulting in projected improvements in the C-5 TNMCM rate.

The ratio between authorized and assigned personnel is typically used to quantify personnel availability. While this ratio is an indicator of maintenance capacity, it provides only a limited

beyond the traditional authorized versus assigned personnel viewpoint. The remainder of this article describes the need for NEP and how the NEP calculations were developed during the *C-5 TNMCM Study II*. The NEP calculations were ultimately used in conjunction with historical demand to propose base-level maintenance capacity realignments resulting in projected improvements in the C-5 TNMCM rate.

Personnel as a Constraint

The analytical methodology applied to the C-5 maintenance system determined that personnel availability was an important factor to consider. This idea is not new; indeed, the force-shaping measures underway in the Air Force have brought the reality of constrained personnel resources to the forefront of every airman’s mind. Without exception, maintenance group leadership (MXG) at each base visited during the *C-5 TNMCM Study II* considered personnel to be one of the leading constraints in reducing not mission capable maintenance hours. The study team heard the phrase “we need more people” from nearly every shop visited:

“The biggest problem for the maintainers here is a shortage of people.”⁵

“With more people we could get a higher MC [mission capable]. We’re currently just scrambling to meet the flying schedule.”⁶

“Hard-broke tails and tails in ISO [isochronal inspection] get less priority than the flyers. We run out of people—we physically run out.”⁷

The Air Force defines total maintenance requirements (authorizations) on the basis of the Logistics Composite Model (LCOM) and current manpower standards. LCOM is a stochastic, discrete-event simulation which relies on probabilities and random number generators to model scenarios in a maintenance unit and estimate optimal manpower levels through an iterative process. The LCOM was created in the late 1960s through a joint effort of RAND and the Air Force Logistics Command. Though intended to examine the interaction of multiple logistics resource factors, LCOM’s most important use became establishing maintenance manpower requirements. LCOM’s utility lies in defining appropriate production levels, but it does not differentiate experience.⁸ Once these requirements are defined, the manpower community divides these requirements among the various skill levels as part of the programming process. Overall, the manpower office is charged with determining the number of slots, or spaces, for each skill level needed to meet the units’ tasks. The personnel side then finds the right *faces*, or people, to fill the spaces.

One measure historically used to quantify personnel availability is the ratio between authorized and assigned personnel. While this ratio is an indicator of maintenance capacity, it provides only a limited amount of information. Authorized versus assigned ratios do not take into account the abilities and skill levels of the maintenance personnel, nor does it factor in the availability of the personnel on a day-to-day basis. These issues were addressed in the *C-5 TNMCM Study II* by quantifying “we need more people” beyond the traditional metric of authorized versus assigned personnel. This capacity

Article Highlights

quantification was done as part of the larger effort of aligning capacity with demand. The process of capacity planning generally follows three steps:

- Determine available capacity over a given time period
- Determine the required capacity to support the workload (demand) over the same time period
- Align the capacity with the demand⁹

The following describes how the study team pursued step 1, determining available capacity over a given time period, using data from the 436 MXG at Dover Air Force Base (AFB) and characterizing the results in terms of what the study team denoted as NEP.

Determining Available Capacity

When personnel availability and capacity are discussed at the organizational level, typically the phrase *authorized versus assigned* personnel is used. However, are all people assigned to maintenance organizations—namely, an aircraft maintenance squadron (AMXS) or a maintenance squadron (MXS)—viable resources in the repair process? Most maintainers will answer no. While it is true that all assigned personnel serve a defined and important purpose, not everyone in these organizations is a totally viable resource to be applied against maintenance demand. This impacts maintenance repair time and aircraft availability.

TNMCM time begins and ends when a production superintendent advises the maintenance operations center to change the status of an aircraft. The length of that time interval is determined by several things. One factor is the speed of technicians executing the repair, which includes diagnosis, corrective action, and testing (illustrated in Figure 1) the repair node of Hecht's *restore-to-service* process model.

As illustrated by the Hecht process model, there are other important components required to return an aircraft to service, but the pool of manpower resources required to support the repair node is critically linked to TNMCM time. Within a mobility aircraft maintenance organization, this pool represents hands-on 2AXXX technicians whose primary duty is performing aircraft maintenance. Specifically, the study team defined the technician resource pool as follows:

Technicians: the collective pool of airmen having a 2AXXX AFSC, that are 3-level or 5-level maintainers, or nonmanager 7-level maintainers whose primary duty is the hands-on maintenance of aircraft and aircraft components.

The distinction of nonmanager 7-levels generally reflects 7-levels in the grades of E-5 and E-6. In active duty units, 7-levels in the grade of E-7 do not typically perform hands-on aircraft maintenance, but are instead directors of resources and processes—they are managers.¹¹ This is in stark contrast to Air National Guard units, where 2AXXX personnel in the senior noncommissioned officer ranks routinely perform *wrench-turning*, hands-on maintenance.¹² For the research detailed in the *C-5 TNMCM Study II*, personnel analysis centered on data from the 436 MXG at Dover AFB and utilized the study team's definition of technicians.

Net Effective Personnel

Authorized versus assigned personnel figures usually quantify the entire unit. With the definition of technicians in mind, it is

amount of information. These ratios do not take into account the abilities and skill levels of the maintenance personnel, nor does it factor in the availability of the personnel on a day-to-day basis. The NEP methodology described in the article is a repeatable process which produces data that provides leadership with a better representation of the personnel resources and actual capacity available to an Air Force aircraft maintenance organization on a day-to-day basis. The NEP methodology will be tested further and validated using personnel data from other units to verify similar results and potential gains. Ultimately, the NEP methodology has the potential to be used alone or in conjunction with the Logistics Composite Model to better portray maintenance personnel requirements and capabilities based on experience and skill levels.

This is the first in a three-part series of articles that examine C-5 TNMCM rates.

Article Acronyms

AFB – Air Force Base

AFLMA – Air Force Logistics Management Agency

AFSC – Air Force Specialty Code

AMXS – Aircraft Maintenance Squadron

ANGB – Air National Guard Base

APG – Aerospace and Powerplant General

CBT – Computer-Based Training

CMS – Component Maintenance Squadron

EMS – Equipment Maintenance Squadron

ETCA – Education and Training Course Announcement

LCOM – Logistics Composite Model

MXG – Maintenance Group

MXS – Maintenance Squadron

NEP – Net Effective Personnel

TDY – Temporary Duty

TNMCM – Total Not Mission Capable Maintenance

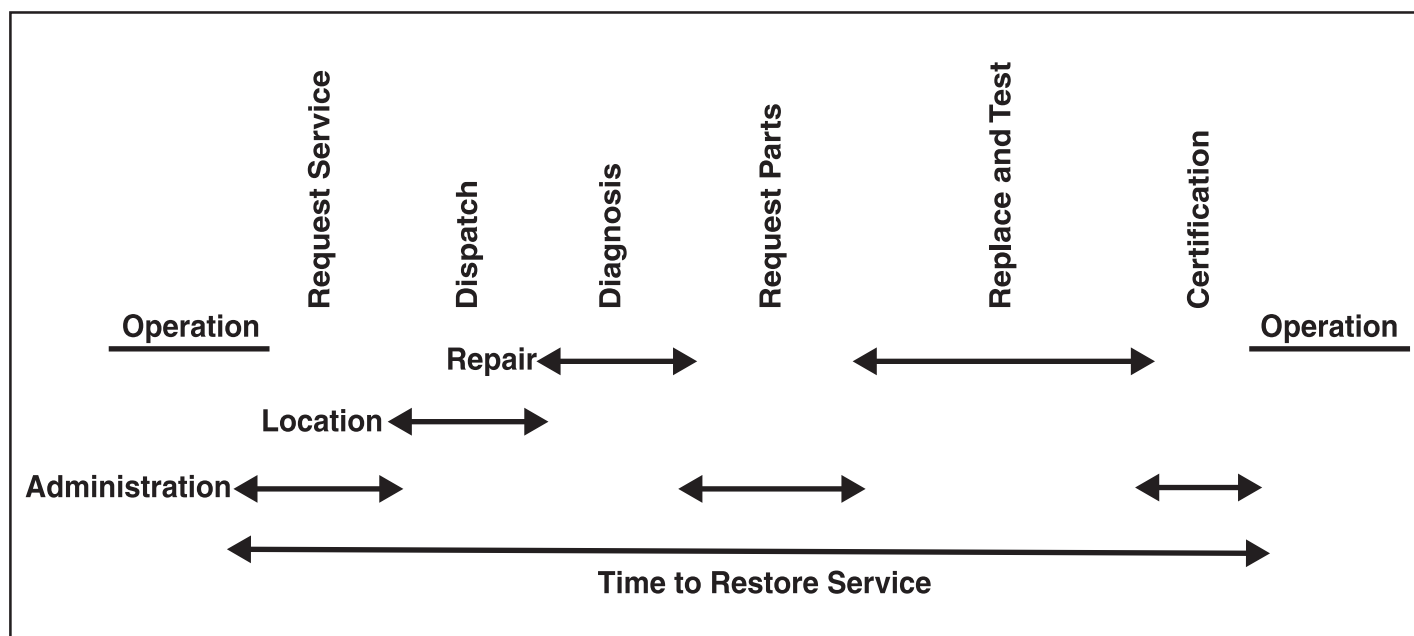


Figure 1. Time to Restore Service Process Model¹⁰

Technician Category	Productivity Factor
Non-manager 7-levels	100%
Non-manager 7-level trainers	85%
5-levels	100%
5-level trainers	85%
3-levels	40%

Table 1. Productivity Factors¹⁵

important to consider three additional factors that introduce variability into the personnel resource pool. These factors are:

- Skill-level productivity
- Ancillary and computer-based training (CBT)
- Availability

The study team examined the influence of these three factors, as well as their impact on the viable resource pool for the 436 MXG. This collective impact yielded a new resource pool representing a depiction of *effective* capacity rather than just the authorized versus assigned ratio. Again, this new resource pool is denoted as Net Effective Personnel, or NEP.

Factor 1: Skill-Level Productivity

In order to accurately examine the quantitative adequacy of a resource, as well as how a resource has historically been used to meet demand, there must be parity among individual resource units. Consider the previous definition of technicians. If one were to select two people at random, would they be equally capable resources? Not necessarily, if one was a 3-level trainee and the other was a 5 or 7-level resource. In order to collectively examine people in terms of comparable resources, and to account for the skill-level variability in typical aircraft maintenance organizations, productivity factors were applied to the resource pool.

As part of this research effort, the study team utilized its strategic partnership with RAND Project Air Force. Through personal interviews with RAND personnel and review of recently

published RAND research, the study team learned that RAND had explored the productivity of trainees and trainers in aircraft maintenance units. Trainees were defined as 3-levels, who are not as productive as 5- and 7-levels. Additionally, some 5- and 7-levels were not as productive as others because they spend time training and instructing 3-level personnel.¹³ In terms of specific productivity based on RAND research, 3-levels were estimated to be 40 percent productive, 5-level trainers and nonmanager 7-level trainers were estimated to be 85 percent productive, and 5-levels and nonmanager 7-levels were 100 percent productive if they were unencumbered with training responsibilities.¹⁴ For the purpose of this analysis, the number of trainers was considered to be equal to the number of 3-levels assigned—a one-to-one ratio. The productivity factors for the viable resource pool are summarized in Table 1.

These productivity factors also are similar to results from additional RAND research at Travis AFB published in 2002.¹⁶ Considering the productivity factors from Table 1, the net effect of these productivity factors alone was a reduction of the 436 AMXS viable resource pool by an average of 5.68 percent.¹⁷

Factor 2: Ancillary Training and Computer-Based Training

In recent times the impact of ancillary training and CBT has been such an important issue for Air Force senior leaders, that it was the sole topic of the airman's Roll Call of 9 February 2007.¹⁸ This document indicated that some active duty airmen spend disproportionate amounts of time on ancillary training, which detracts from their ability to perform official duties. Moreover, the document suggested that some ancillary training may no longer be relevant.¹⁹ In the context of the viable pool of aircraft maintenance technicians, this would mean that, some of the time, personnel resources may be on duty but unavailable to perform hands-on maintenance due to an ancillary training requirement.

A consensus majority of personnel interviewed during the study team's site visits echoed these concerns, describing an *insidious growth* of new training requirements in recent years.²⁰ An additional concern voiced by interviewees pertained to

computer resources. Interviewees described a situation where office workers have ready access to a personal computer (PC), but dozens of maintenance technicians often share only a handful of communal PCs. Consequently, their ability to complete computer-based ancillary training is constrained. One unit training manager explained that in the past, a group training briefing would be conducted for an entire work center, fulfilling each individual's training requirement simultaneously.²¹ Today, an online course issues the required certificate of completion for only one individual, thereby necessitating that each airman conduct the training individually. The net result is more time away from primary duties (for example, repairing aircraft). In order to assess the influence of ancillary training and CBT on the technician resource pool, the study team quantified the average daily impact.

A list of various ancillary and computer-based training items that are applicable to the relevant pool of aircraft maintenance personnel was collected from three data sources:

- The USAF Education and Training Course Announcement (ETCA) Web site²²
- The unit training monitor at the AFLMA
- The unit training monitor for the 105 MXG at Stewart Air National Guard Base (ANGB)

The training was categorized by data source, course number (if applicable), and course name. Training was also categorized as follows.

- Mandatory for all personnel, such as law of armed conflict training
- Voluntary or job-specific, such as hazardous material management training

Also, requirements were identified by the recurrence frequency (one-time, annual, or semiannual). Some requirements are aligned with the 15-month aerospace expeditionary force cycle; this would equate to a yearly recurrence frequency of 0.8 (12/15). Finally, training was categorized by the duration in hours for each requirement as identified by the data sources.

Most training courses only take up a portion of the duty day. The average duration for courses considered was 2.8 hours, with many listed at one hour or less. In situations like these, a manager would still view the individual as *available* for the duty day.²³ Therefore, the study team examined the impact of CBT and ancillary training as a separate factor and not as a part of the availability factor (factor 3). Final calculations resulted in the following totals:

- Hours of mandatory one-time training (denoted M_o), 101.5 hours

- Hours of mandatory annually-recurring training (M_a), 67.2 hours
- Voluntary or job-specific one-time training (VJS_o), 85.8 hours
- Voluntary or job-specific annually-recurring training (VJS_a), 10.3 hours

In order to quantify the daily impact of these training items, the study team made the following assumptions:

- An 8-hour workday
- 220 workdays in a calendar year. (5 days per week x 52 weeks per year) = 260; 260 – (30 days annual leave) – (10 federal holidays²⁴) = 220 workdays
- 3-levels required all of the mandatory, one-time training
- 5-levels and 7-levels required only the annually-recurring portion of the mandatory training
- As an average, all 3-levels required 10 percent of the voluntary or job-specific, one-time training
- As an average, all 5-levels and 7-levels required 10 percent of the voluntary or job-specific, one-time, annually-recurring training
- As an average, all training durations would be increased 20 percent to account for travel, setup, and preparation²⁵

When employing the above assumptions, the figures in Table 2 were calculated to be best estimates of the time impact of ancillary training and CBT.

The best estimates for CBT and ancillary training requirements account for 7.51 percent and 5.24 percent of the workday for 3-, 5-, and 7-levels, respectively. The complementary effectiveness rates for this factor are expressed as 0.9249 ($1 - 0.0751$) for 3-levels and 0.9476 ($1 - 0.0524$) for 5 and 7-levels. These rates are listed as the ancillary and CBT factors for 3-, 7-, and 5-levels respectively in Table 6.

Table 3 illustrates how these rates change when the percentages of voluntary and job-specific training (V/JST) or the percentage of travel and setup buffer are varied. The matrices in Table 3 illustrate the results of sensitivity analysis of various CBT and ancillary training factors that would result for combinations of voluntary or job-specific training, or travel and setup buffer ranging from zero to 25 percent. The range of all calculated factors is approximately 3 percent for both technician categories. Note that the CBT and ancillary training factors chosen utilizing the study team's assumptions are boxed and shaded. For both 3-, 5-, and 7-levels, the calculated training factors fall very near the mean developed in the sensitivity analysis. Some values shown in Table 3 are the result of rounding. For the 436 MXG at Dover AFB, the net effect of these CBT and ancillary training factors alone was a reduction of the viable resource pool by an average of 1.58 percent.²⁶

Technician	Hours per Year	Hours per Workday	Percentage of 8-Hour Workday	Minutes per Workday
3-level	132.10	0.60	7.51%	36.03
Formula	$1.2(M_o + (0.1VJS_o))$	(Hrs/yr)/220	(Hrs/workday/8)*100	(Hrs/workday)*60
5- / 7-level	92.17	0.42	5.24%	25.1
Formula	$1.2(M_a + (0.1(VJS_a + VJS_o)))$	(Hrs/yr)/220	(Hrs/workday/8)*100	(Hrs/workday)*60

Table 2. Best Estimate of CBT and Ancillary Training Time Requirements

3-Levels						
% Travel/Setup Multiplier						
% V/JST	1	1.05	1.1	1.15	1.2	1.25
0.00	0.942	0.939	0.937	0.934	0.931	0.928
0.05	0.940	0.937	0.934	0.931	0.928	0.925
0.10	0.937	0.934	0.931	0.928	0.925	0.922
0.15	0.935	0.932	0.929	0.925	0.922	0.919
0.20	0.933	0.929	0.926	0.922	0.919	0.916
0.25	0.930	0.927	0.923	0.920	0.916	0.913
5- and 7-Levels						
% Travel/Setup Multiplier						
% V/JST	1	1.05	1.1	1.15	1.2	1.25
0.00	0.962	0.960	0.958	0.956	0.954	0.952
0.05	0.959	0.957	0.955	0.953	0.951	0.949
0.10	0.956	0.954	0.952	0.950	0.948	0.945
0.15	0.954	0.951	0.949	0.947	0.944	0.942
0.20	0.951	0.948	0.946	0.944	0.941	0.939
0.25	0.948	0.946	0.943	0.940	0.938	0.935
Descriptive Statistics						
	Mean	Min	Max	Range		
3-Level	0.928	0.913	0.942	0.030		
5- and 7-Level	0.949	0.935	0.962	0.027		

Table 3. CBT and Ancillary Training Factor Sensitivity Analysis

		3-Level	5-Level	7-Level	Total	% of Total
Reason Unavailable	Assigned	32	28	22	82	100%
	Temporary Duty		6	4	10	12%
	Qualification and Training Program	9			9	11%
	Detail	2	3	2	7	9%
	Leave	2	3	2	7	9%
	Scheduled Off Day	2	1	2	5	6%
	Medical Profile		2	1	3	4%
	Part-day Appointment	1	1	1	3	4%
	Full-day Appointment			2	2	2%
	Compensatory Off Day			1	1	1%
	Flying Crew Chief Mission		1		1	1%
	Out Processing		1		1	1%
	Permanent Change of Assignment		1		1	1%
	Field Training Detachment Course		1		1	1%
	First Term Airmen's Center	1			1	1%
	Bay Orderly	1			1	1%
	Available	14	8	7	29	35%

Figure 2. 436 AMXS APG Day Shift Personnel Availability Snapshot²⁷

Factor 3: Availability

Manpower resources must be present to be viable, and on any given day, aircraft maintenance organizations lose manpower resources due to nonavailability. Examples include temporary duty (TDY) assignments, sick days, and other details. To illustrate, Figure 2 depicts the actual availability of 436 AMXS airframe and powerplant general (APG) technicians on day shift for Thursday, April 12, 2007. For this work center, on this particular day and shift, roughly 65 percent of assigned technicians were not available for the various reasons listed.

Much like aircraft maintenance, some events that take people away from the available pool are scheduled and known well in advance, while others are unexpected, such as illnesses and family emergencies.

Although scheduled and unscheduled events both have an impact, scheduled events are anticipated and can be planned for. Adjustments can be made and resources can be shifted. Consequently, resource managers want to monitor and manage scheduled personnel nonavailability to the greatest extent possible. In order to assess the impact of this factor on the resource pool, the study team monitored the personnel availability of the 436 AMXS at Dover AFB from 1 March through 30 April 2007 via 9 weekly snapshots. 436 AMXS supervision tracks manpower via a spreadsheet tool that identifies the availability status of each assigned 3-level, 5-level, and nonmanager 7-level in their hands-on maintenance resource pool. For AMXS, this represents technicians from six different shops, identified with the corresponding Air Force specialty codes (AFSC) as follows:

- Airframe and Powerplant General (APG) – 2A5X1C, 2A5X1J
- Communication and Navigation (C/N) – 2A5X3A
- Electro/Environmental Systems (ELEN) – 2A6X6
- Guidance and Control (G/C)²⁸ – 2A5X3B
- Hydraulics (HYD) – 2A6X5
- Engines (JETS) – 2A6X1C, 2A6X1A

The AMXS snapshot spreadsheet is updated (but overwritten) continually as status changes occur.²⁹ By monitoring changes in these snapshots, the study team was able to examine not only the impact of personnel nonavailability in aggregate, but also the degree to which the discovery and documentation of events altered the size of the capacity pool. Using the Dover AMXS snapshots, the study team calculated the number of available technicians in the aircraft maintenance resource pool.

The study team monitored the actual availability figures for the 436 AMXS over the 9-week period of March and April 2007, for a total of $n = 61$ daily observations. Across all shifts, the total number of personnel assigned to the AMXS personnel resource pool was 411 for the month of March, and 412 for the month of April. Actual availability figures, however, were much lower. Table 4 summarizes the descriptive statistics of this analysis.

The upper row of Table 4 statistics reflects the actual number of technicians available, while the bottom row reflects that number as a percentage relative to the total number of technicians assigned. For example, in the month of March, the maximum number of available technicians observed was 202, or 49 percent (202 of 411) of the total assigned. The mean availability for March was 36 percent. These figures take into consideration that some of the nonavailable personnel may be performing duties elsewhere for the Air Force such as flying crew chief missions or other TDY assignments. Therefore, they would not be viable assets for the aircraft maintenance resource pool at Dover AFB. The net effect of this nonavailability factor was a reduction of the AMXS home station viable resource pool by an average of

65.39 percent. This is reflected as the 35 percent mean highlighted for March-April 2007.

As discussed previously with Factors 1 and 2, the productivity of available technicians is reduced due to skill-level training needs, as well as ancillary and CBT training requirements. The study team applied productivity factors from Table 1 and CBT and ancillary training factors from Table 2 to the observed number of available technicians in AMXS. These calculations quantified the final pool of viable personnel resources, which is denoted as NEP. Because of daily variations in the number of 3-, 5-, and 7-skill level technicians available, the factors were applied to each daily observation. In performing these calculations, the study team developed a representation of the effective personnel resource pool. Specifically, the NEP figures account for the realities of availability and productivity, and allow the resource pool to be viewed objectively, unconstrained by concerns such as skill-level differences. The value of such a resource picture is that it provides a suitable mechanism for comparing maintenance capacity (NEP resource pool) with maintenance demand. The summary descriptive statistics for the 436 AMXS NEP are indicated in Table 5. Averaging across the observed timeframe, the 436 AMXS had approximately 113 net effective technicians in its viable resource pool on any given day. This figure is approximately 27 percent of the total assigned quantity of technicians, again using the previously discussed definition for technicians.

Therefore, to arrive at the results shown in Table 5, the study team considered the factors from Table 1 and 2, as well as the ancillary and CBT factors complimentary effectiveness rates calculated.

Each factor and rate detailed to this point was assigned a new designation for ease of use in the proposed NEP equation. The newly designated factors, factor descriptions, and the associated values are listed in Table 6.

The T factors relate to training, the A factors relate to available personnel, and the P factors relate to productivity. These factors

411 Assigned	March 07				April 07				March-April 07			
	Min	Max	Mean	Range	Min	Max	Mean	Range	Min	Max	Mean	Range
Available	100	202	147	102	104	163	137	59	100	202	142	102
% of Assigned	24%	49%	36%	25%	25%	40%	33%	14%	24%	49%	35%	25%

Table 4. 436 AMXS Availability Descriptive Statistics

411 Assigned	March 07				April 07				March-April 07			
	Min	Max	Mean	Range	Min	Max	Mean	Range	Min	Max	Mean	Range
Available	79	167	120	88	77	124	105	47	77	167	113	90
% of Assigned	19%	41%	29%	21%	19%	30%	26%	11%	19%	41%	27%	22%

Table 5. 436 AMXS NEP Descriptive Statistics

Factor	Description	Value
T_{75}	Ancillary/CBT Factor for 7- and 5-levels	0.948
A_{75NT}	The number of available nonmanager 7-levels and 5-levels who are not trainers	Varies day-to-day
P_t	Trainer Productivity	0.85
A_{75T}	The number of available nonmanager 7-levels and 5-levels who are trainers	Varies day-to-day
T_3	Ancillary/CBT Factor for 3-levels	0.925
P_e	Trainee Productivity	0.4
A_3	The number of available 3-levels	Varies day-to-day

Table 6. NEP Factors

were applied to the number of available technicians as recorded in the AMXS availability snapshots using the newly proposed NEP calculation, shown as Equation 1. Equation 1 is the cumulative NEP equation which accounts for all three factors which create variability in the resource pool and yields a numerical quantity of net effective personnel. To determine the NEP percentage, one need simply divide the right side of the equation by the number of assigned technicians (7-level nonmanagers, 5-levels, and 3-levels).

Figure 3 provides an Excel spreadsheet snapshot of an example NEP calculation for a generic maintenance unit. The maintenance unit's NEP is calculated using Equation 1 by entering the personnel totals in each of the five categories in the left column. These values are then multiplied by the factors in the right column to determine NEP. In this example, the unit has 104 technicians available but the NEP is only 77. In other words, the practical available maintenance capacity is only 77 technicians, not 104 as it initially appears.

To summarize, the study team's arrival at NEP followed an iterative sequence of three factor reductions:

- Skill-level productivity differences, to include those for trainees and trainers
- Ancillary training and CBT
- The nonavailability of personnel

$$NEP = T_{75} (A_{75NT} + (P_t A_{75T})) + T_3 (P_e A_3)$$

Equation 1. Net Effective Personnel

# of available 3-levels	30	CBT Factor (3-levels)	0.925
# of available 5-levels who are trainers	30	CBT Factor (5/7-levels)	0.948
# of available 5-levels who are not trainers	32	Productivity Factor (trainees)	0.400
# of available non-manager 7-levels who are trainers	0	Productivity Factor (trainers)	0.850
# of available non-manager 7-levels who are not trainers	12		
NEP	77.0		

Figure 3. Example NEP Calculation

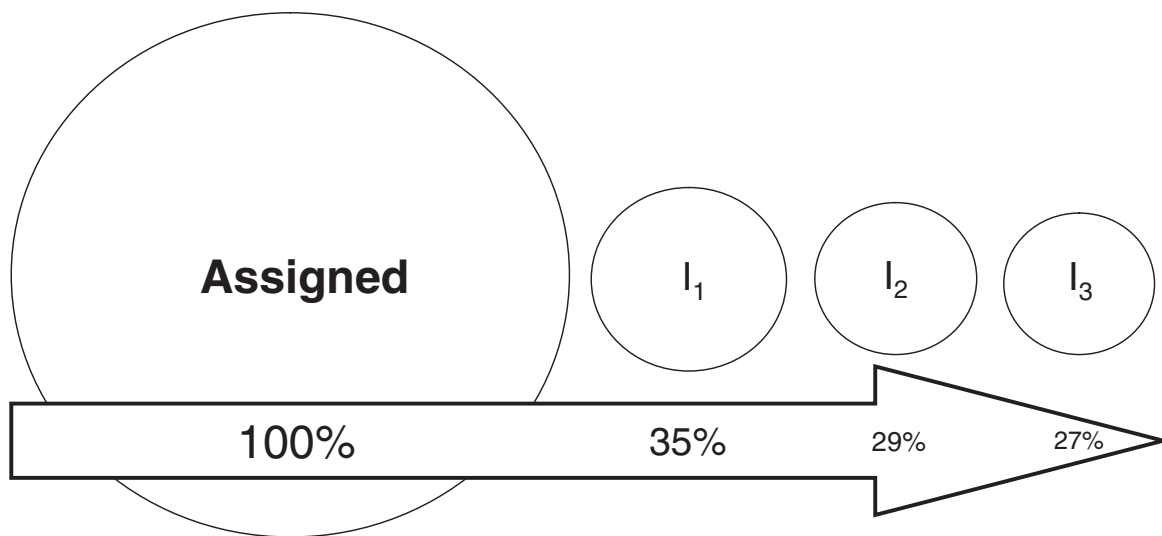
Figure 4 graphically illustrates these iterations based on the relative size of the impact of the three factors on reductions to the overall resource pool. As shown in Figure 4, nonavailability had the biggest impact, productivity factors were next, and finally the effect of CBT and ancillary training had the smallest impact.

In addition to AMXS, an Air Force Maintenance Group usually includes a separate equipment maintenance squadron (EMS) and component maintenance squadron (CMS). However, if total authorizations are under 700, EMS and CMS will be combined into a maintenance squadron such as the MXS at Dover AFB. Various flights within a typical MXS maintain aerospace ground equipment, munitions, off-equipment aircraft and support equipment components; perform on-equipment maintenance of aircraft and fabrication of parts; and provide repair and calibration of test, measurement, and diagnostic equipment.³⁰ Technicians assigned to MXS usually perform maintenance not explicitly linked to the launch and recovery of aircraft (as is the focus of AMXS). However, some MXS personnel directly support flight line activities.

A more complete representation of the net effective personnel pool for aircraft maintenance resources in an MXG would include not only personnel in AMXS, but also those in MXS. The number of nonmanager 7-levels, 5-levels, and 3-levels assigned to the 436 MXS was determined from Air Force Personnel Center data

to be 318.³¹ Using the study team's definition of technician, this results in 729 technicians in the 436 MXG (411 in AMXS plus 318 in MXS). However, because the study team could not obtain exact daily availability figures for MXS similar to those of AMXS, the study team applied each of the calculated daily NEP percentages for AMXS against the number of assigned technicians to MXS. This calculation yielded daily estimates of the number of NEP for MXS. Since AMXS and MXS are both aircraft maintenance units with many of the same AFSCs and similar demands on their personnel, any differences from actual numbers as a result of this method were considered negligible for this analysis.

The study team then added the AMXS NEP figures to the MXS NEP figures, resulting in a collective NEP figure for the flight line maintainers at Dover AFB. These collective NEP



- Iteration 1 (I_1) : Availability
 - $A_{75NT} + A_{75T} + A_3$
- Iteration 2 (I_2) : Availability and Productivity
 - $A_{75NT} + P_t A_{75T} + P_e A_3$
- Iteration 3 (I_3) : Availability, Productivity, CBT and Ancillary Training
 - $T_{75}(A_{75NT} + P_t A_{75T}) + T_3(P_e A_3)$

Figure 4. The Iterations of NEP

figures are shown in Table 7. The upper portion of the table shows the NEP figures grouped by columns (day of the week) with each row representing 1 of the 9 weeks over the entire period that data was tracked. The bottom section of Table 7 also displays the descriptive statistics for NEP across both AMXS and MXS combined. The highest average NEP value was 222 on Thursdays, representing approximately 30 percent of the baseline total of 729 people.

Conclusion

The ratio between authorized and assigned personnel is typically used to quantify personnel availability. While this ratio is an indicator of maintenance capacity, it provides only a limited amount of information. These ratios do not take into account the abilities and skill levels of the maintenance personnel, nor does it factor in the availability of the personnel on a day-to-day basis. The Net Effective Personnel methodology described in this article is a repeatable process which produces NEP figures that provide leadership with a better representation of the personnel resources and actual capacity available to an Air Force aircraft maintenance organization on a day-to-day basis. The NEP methodology will be tested further and validated using personnel data from other units to verify similar results and potential gains. Ultimately, the NEP methodology has the potential to be used alone or in conjunction with LCOM to better portray

maintenance personnel requirements and capabilities based on experience and skill levels.

As previously mentioned, the NEP methodology described in this article was developed as part of the larger *C-5 TNMCM Study II*. The entire study can be found at the Defense Technical Information Center Private Scientific and Technical Information Network Web site at <https://dtic-stinet.dtic.mil/>.

End Notes

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	Day of the Week NEP Distributions						
	Sun	Mon	Tue	Wed	Thu	Fri	Sat
NEP	186	219	228	211	259	219	187
	148	209	226	219	213	182	140
	153	212	211	242	219	195	155
	188	242	289	297	245	205	169
	165	210	220	216	294	235	198
	137	186	187	195	205	175	148
	173	206	192	188	194	176	168
	167	213	201	195	183	186	174
	176	203			185	194	180
n	9	9	8	8	9	9	9
Min	137	186	187	188	183	175	140
Max	188	242	289	297	294	235	198
Mean	166	211	219	221	222	196	169
% of Assigned	23%	29%	30%	30%	30%	27%	23%
Range	51	56	102	109	110	59	58
Variance	300	221	1031	1241	1385	404	349
Standard Dev	17	15	32	35	37	20	19

Table 7. Day of the Week NEP Distributions for 436 MXG (AMXS and MXS)³²

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26. 436 AMXS/MXAA.
27. Data for 12 April 2007, 436 AMXS/MXAA, Dover AFB.

28. G/C is alternatively known as Automatic Flight Controls & Instruments.
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32. Values in Table 7 are rounded to nearest whole number.

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There is no indication that the future will see a decrease in fuel prices, so organizations must increase fuel economy.

contemporary issues

Analysis: KC-135 Lean Fueling Operations Meeting the Army's Equipping Challenge

Contemporary Issues in this edition presents two articles: "Analysis: KC-135 Lean Fueling Operations" and "Meeting the Army's Equipping Challenge."

In "Analysis: KC-135 Lean Fueling Operations" Major Bruce P. Heseltine, USAF, outlines how the use of lean and just-in-time fueling procedures, coupled with the development of a tanker dispatch system, would enable the KC-135 community to markedly improve mission planning using a fixed targeted shutdown fuel quantity. Under this approach, aircraft would be loaded with only the fuel needed to accomplish a given mission, while significantly reducing unnecessary ferrying of fuel. The net result would be a decrease in the amount of fuel required (or purchased) each year. Further, the concepts and findings addressed in this article could be tailored to various Air Mobility Command (AMC) aircraft mission processes. AMC is the largest consumer of fuel in the DoD, and flew over 142,000 sorties in 2005. If \$200 were saved on every sortie the command could save over \$28M per year. While \$28M is a significant amount of money, initial indications show the possibility of savings in excess of \$160M per year through the application of major fuel efficiency initiatives across the command.

Colonel Jim Campbell, USA, in "Meeting the Army's Equipping Challenge" explores the United States Army's current equipping strategy, and suggests the modifications needed to help create conditions and metrics to assess current equipment requirements as well as requirements for the future. Campbell argues that first, it would be beneficial for the Army to modify readiness assessments of equipment required for mission accomplishment, and to develop metrics that more accurately reflect actual mission essential needs (including unit status report methodology). Second, a modified program similar to the Army Prepositioned Stock program is needed that is capable of rotational operations to facilitate the use of prepositioned equipment in current and future contingency operations. Finally, increased budgetary allocations specifically tied to achieving equipping strategies with improved acquisition programs and increased efficiency of the US industrial base will potentially increase the amount of military specific equipment available for use by soldiers. Alone, these measures will have a minor impact on the current situation, but taken collectively they provide a potential solution to overcome the current equipping dilemma facing the Army.

Analysis: KC-135 Lean Fueling Operations

Bruce P. Heseltine, Jr, Major, USAF

Introduction

Over the past several years, fuel costs have risen dramatically. At the same time, United States Air Force Air Mobility Command (AMC) is facing some very significant challenges.

- Personnel cuts
- Engaging in the Global War on Terror
- Aggressively working to recapitalize its aging KC-135 tanker fleet
- Reduced budgets and ever-increasing oil prices
- Inefficient operational practices

Changes must be made to reduce consumption of fuel, while maintaining mission effectiveness. This paper addresses significant potential cost savings associated with the implementation of an aggressive *lean* fuel savings initiative in the KC-135 community.

Lean

It is important to lay the foundation of what is meant by a *lean fuel initiative*. Womack and Jones define the basic principals of Lean¹ as

- Specifying Value
- Identifying the Value Stream
- Flow
- Pull
- Perfection

The *Specific Value* of this fuel savings proposal is an enhanced, effective, mission planning and execution program that achieves greater efficiencies through reductions in fuel consumption. As the product in this case is an air refueling mission, the *Value Stream* consists of all specific actions required to achieve mission success, both on the ground and in the air. In the KC-135, *Flow* starts with mission scheduling and planning, and includes every step in the process until both the aircraft and aircrew are assigned their follow-on mission tasking. The goal in addressing flow is to identify steps in the process that are wasteful. In other words, what steps are aircrews and mission support personnel taking that are not necessary to accomplish the mission? The *Pull* step in the lean tanker process entails the allocation of fuel to assigned or tasked aircraft and aircrew mission planning and execution. The goal is to identify extraneous actions or waste while continuing to meet the mission needs. Implementing a plan to transition fueling from a standard ramp load to *as required* to meet mission requirements would help achieve this goal. Finally, the *Perfection* step in the lean fuel process occurs



by thoroughly assessing post-mission data to determine if the mission was flown as efficiently as possible and to further identify areas for improvement. This thorough review can identify trends in daily operations, lead to the development of tabulated data that could speed the mission planning process, and eliminate steps deemed nonessential to the success of the mission.

Enhanced fuel efficiency can be achieved without compromising mission effectiveness, and a lean fuel savings initiative would not sacrifice the world class capability of Air Mobility Command's (AMC) tanker fleet. The International Air Transportation Association (IATA) asserts that accurate and efficient fuel management will actually improve safety because it requires additional attention, accuracy, increased situational awareness, and can reduce overall fuel budget by 5 percent.² To achieve enhanced mission efficiencies, this article proposes a *leaning* of the current KC-135 mission planning process and the elimination of the currently practiced standard ramp fueling procedures. The goal is to "instill a culture of *energy awareness* in the planning, scheduling, and execution of all AMC activities, from support through training to mission execution."³

This article identifies ways to reduce the daily and annual costs of flying AMC KC-135 aircraft by utilizing industry practices to enhance mission fuel efficiencies. These practices are also applicable to Air Education and Training Command (AETC) since their KC-135 missions are analogous to those flown by AMC. The objective is to make this as low cost as possible using current off-the-shelf technology for data analysis (primarily Microsoft Excel) as well as incorporating preexisting infrastructures available at each flying unit in AMC and AETC.

This article demonstrates that the use of lean and just-in-time (JIT) fueling procedures, coupled with the development of a tanker dispatch system, would enable the KC-135 community to accomplish highly efficient mission planning using a fixed targeted shutdown fuel quantity. Therefore, aircraft would be loaded with only the fuel needed to accomplish a given mission, while significantly reducing unnecessary ferrying of fuel. The net result would be a decrease in the amount of fuel required (or purchased) each year.

The following questions are addressed in this article.

Do AMC and AETC KC-135s ferry unneeded gas?

What course or courses of action should AMC and AETC take to improve tanker fuel efficiency?

A review of the applicable literature led to the following research hypothesis: Implementing airline and cargo industry

practices of fueling aircraft only as necessary to meet mission requirements will increase KC-135 fuel efficiency.

Historic Fuel Practices

Traditionally, KC-135 aircraft have been fueled to the maximum load for a worst-case mission scenario which affords maximum flexibility. This practice, generally, is accomplished the night before a planned mission. Air Force Instruction (AFI) 11-2KC-135V3 states, "Units may develop standard ramp loads that meet the minimum local training mission requirements or emergency evacuation requirements (whichever is less)."⁴ However, the most common standard ramp load is 80,000 pounds, which far exceeds either of the above requirements. A limitation to an amended fueling practice is the perception that refueling aircraft the night before is essential, because units do not have adequate capability (manpower or equipment) to fuel aircraft just a few hours prior to the flight. The first hurdle is to overcome this mindset and demonstrate how changing the standard refueling sequence of events is in everyone's best interest.

Aviation industry success is very cyclic in nature. Declining profits are quite often a direct result of rising fuel prices. According to one industry estimate, every one cent per gallon increase costs the industry \$160M.⁵ In the late 1960s, fuel cost 10.4 cents per gallon, and between 1967 and 1972, aviation fuel prices rose at an annual rate of just 2.6 percent.⁶ In 1974 the average price per gallon soared 90 percent to 24.2 cents in just 1 year. By 1977 fuel prices averaged 36.2 cents per gallon—a 248 percent increase from 1968. The Organization of Petroleum Exporting Countries fuel crisis of the 1970s caused Department of Defense (DoD) leaders to focus on fuel savings. A RAND Corporation study said that "over the next 50 years fuel reserves [will] continue to be depleted and as supplies diminish, prices will escalate and availability will become less certain both home and abroad."⁷ Furthermore, the authors concluded, "to meet the challenge the Air Force [the largest DoD consumer of jet fuel] will be obliged to undertake measures to conserve jet fuel."⁸

From 1978 to 1981, the price of jet fuel increased by over 153 percent. The mid to late 1980s saw a rebound in the economy, and fuel savings initiatives were all but shelved. The Iraqi invasion of Kuwait caused a significant spike in fuel prices, and in October 1990, fuel prices rose from 60 cents a gallon to a peak of \$1.40.⁹ However, industry losses shrank again in 1994 as a result of lower fuel prices. From the late 1990s to the present, fuel prices have steadily risen. Fuel price increases in 2006 caused the DoD and Air Force leadership to once again become serious about savings across the fleet. In 1996 the DoD price for one gallon of aviation fuel was 77 cents, as shown in Figure 1. By 2006 the cost per gallon had skyrocketed nearly 200 percent with the most dramatic increase occurring from 2005 to 2006, when prices rose from \$1.50 to \$2.23 per gallon.¹⁰

There is no indication that the future will see a decrease in fuel prices, so organizations must increase fuel economy. According to IATA, a 1 percent improvement in fuel efficiency across the airline industry can lower fuel costs by \$700M.¹² The Department of Transportation has set the goal of improving fuel efficiency per revenue plane mile by 1 percent per year through 2009 which they estimate will save commercial carriers \$2B per year.¹³

Article Acronyms

AETC – Air Education and Training Command
AFB – Air Force Base
AFI – Air Force Instruction
AFSAB – Air Force Scientific Advisory Board
AMC – Air Mobility Command
CRE – Corporate Real Estate
DoD – Department of Defense
IATA – International Air Transportation Association
JIT – Just in Time
KIAS – Knots Indicated Airspeed
PMAT – Post-Mission Assessment Tool

Fuel Savings Options

The Air Force has identified several methods to save fuel. The Air Force Scientific Advisory Board (AFSAB) indicated the potential for a 5 percent increase in fuel efficiency through “optimization of aircraft operations, engine out taxi, optimum auxiliary power unit usage and optimal route planning.” AFSAB identified this as one of its top near-term *operational* solutions.¹⁴ AMC Pamphlet 11-3 states that one way to conserve fuel during the approach and landing phase of flight is to fly short vectors and delay configurations until close to final approach.¹⁵ Early flap and gear extension can cost up to 100 pounds per minute, and fuel flow increases approximately 50 percent when configured. A recent study of KC-135 pattern operations identified the potential savings of completely retracting the flaps during instrument pattern operations. The standard practice is for KC-135s to fly crosswind and downwind portions of the radar pattern with flaps extended to the 20 degree setting. These patterns are currently flown at approximately 180 knots indicated airspeed (KIAS) and can take as long as 15 to 20 minutes per pattern. The study discussed benefits of flying the pattern at speeds of 220 KIAS with the flaps up to decrease pattern time and increase fuel efficiency. Data indicates that this modified pattern flown by KC-135s at Altus Air Force Base (AFB), Oklahoma, could result in a \$1M to 1.5M annual fuel savings (2.4 percent) as well as potentially generating up to 18 additional flying hours per month.¹⁶

Additional significant fuel savings could be attained through the use of reduced engine operations during ground taxi. Several commercial carriers have studied taxiing on one engine whenever possible and in the case of American Airlines, this practice has resulted in a 30 percent fuel reduction and \$4M in annual savings.¹⁷ Though the KC-135 is a four engine aircraft, there is no requirement to taxi with all four engines running. However, special considerations must be made for unique KC-135 hydraulic and electric systems requirements, which could be met by starting and taxiing using only the number 3 and number 2 (inboard) engines. Additionally, a training and certification syllabus must be developed for two-engine taxi operations prior

to implementation, because as IATA states, “crews who never use engine out taxi procedures will consider them awkward, while crews who consistently use them will consider them routine.”¹⁸

During a site visit to JetBlue Airlines, the manager of JetBlue University technical operations discussed actions the organization has taken to improve fuel savings. Of particular note was the development of a corporate real estate (CRE) unit which addresses various opportunities for savings within the JetBlue organization. According to a CRE memorandum, “With the costs of fuel skyrocketing we knew that if we could carry less fuel but still have a safety margin there would be a savings of \$5.2M by not carrying the extra fuel.”¹⁹ To further illustrate the value of carrying less fuel, the Dallas Business Journal reported American Airlines had saved \$90M per year simply by reducing international and domestic planned ramp arrival fuel.²⁰

The AFSAB has identified that enhanced tracking and reporting of Air Force fuel utilization has the potential to achieve fuel savings of up to 3 percent.²¹ AMC is the largest consumer of the 2.6 billion gallon Air Force fuel supply, using 1.4 billion gallons per year. Using a \$2.50 per gallon assumption, the potential savings equates to approximately \$106M per year by changing tracking and reporting procedures alone. The JetBlue CRE provides a model for how the Air Force could address fuel savings. JetBlue has worked to reduce arrival fuels in their Airbus A320 aircraft by reducing the expected fuel on board from 8,500 - 9,500 pounds to 7,500 pounds, a 12 to 21 percent decrease at one location (they have done the same for all their expected arrival locations). In addition, JetBlue is currently developing plans that make corrections for weather conditions and forecasts. Overall, the aggressive initiatives of the CRE have garnered \$8.2M savings for JetBlue.²²

Traditionally, KC-135 initial qualification pilots are trained to mission plan using a *clean-slate* approach, meaning the crews are presented with a specified mission profile and a fixed amount of fuel to accomplish the mission. Mission requirements are generally takeoff, then aerial refueling, followed by two or more hours of proficiency training. Each aircraft is normally fueled with 80,000 pounds, a very common standard fuel load, and crews

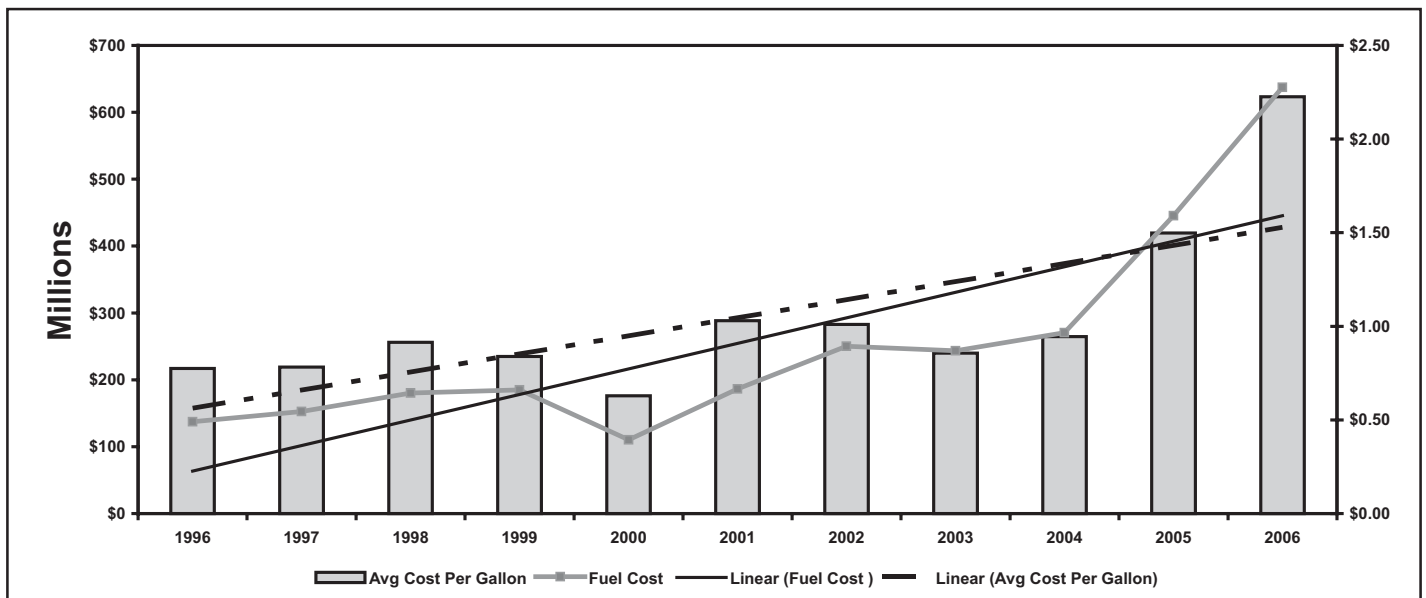


Figure 1. Department of Defense Fuel Prices¹¹

are directed to “make the mission happen.” A review of nearly 3,500 Altus AFB KC-135 missions over 13 months revealed the average shutdown fuel, given an 80,000 pound standard ramp fuel load, was 33,000 pounds. McConnell AFB local procedures set 15,000 to 25,000 pounds as the mission goal, and Grand Forks AFB local procedures set 25,000 as the normal planned arrival fuel.^{23,24} Assuming a good target shutdown fuel would be 20,000 pounds, the missions flown at Altus AFB land with an average of 13,000 pounds more fuel than is necessary. This seems excessive given that Altus AFB KC-135 aircrews are required to land with a minimum of 15,000 pounds of fuel on board. The commercial aviation industry has recognized the impact of carrying extra fuel. By eliminating extra fuel, American Airlines is cutting an average of 30 minutes flying time, saving 30 million gallons and \$50M in annual costs without compromising safety.²⁵

The critical key to oversight of mission validation and execution, and ensuring KC-135 crews are operating aircraft in an efficient manner, is an operations and logistics unified dispatch. An important point to make is that this article does not favor a top-down command and control management of the missions from higher headquarters; rather it is advocating what Seddon describes as *local control* found in companies such as Toyota, which places control at the point where the work is done.²⁶ In the KC-135 case, control would rest with individual dispatch centers, which would remain autonomous and free to schedule missions and make appropriate decisions based on their locations with the mandate that they rigorously pursue the fuel efficiency goals and programs established by AMC headquarters. Using the JetBlue model for decisionmaking, AMC should present the command’s fuel efficiency directives, offer units tools (equipment, instructional guidance, and experience) to help them succeed, and then empower them to do so. The following is the JetBlue statement on empowerment: “The decisions you make should be based on our Values—which should be your Values. If they are, your decisions will be fully supported.”²⁷

Two good Air Force models already in existence for mission dispatch operations can be observed at McGuire AFB, New Jersey, and Fairchild AFB, Washington. Both develop mission activity and plan fuel loads to meet mission requirements in accordance with published directives. Utilizing a central dispatch system, Fairchild AFB KC-135 crews achieved an average shutdown fuel 6,000 pounds below the AMC KC-135 average, based on a review of 462 missions. This was accomplished with the Fairchild AFB Fuel Planning Matrix, which outlines fuel targets to be used during mission planning. For example, mission planners adjust the target shutdown fuel based on current weather forecasts.²⁸

To further improve fuel efficiency, central dispatchers should consider reviewing and implementing items listed on the IATA Fuel and Emissions Efficiency Checklist. This checklist enables managers to audit their current fuel practices to ensure they are taking advantage of all available avenues to reduce fuel.²⁹ A review of the IATA checklist yielded the sample of questions included in Table 1, which could pertain to KC-135 dispatch operations. This list is not all encompassing; rather it is meant to illustrate the usefulness of the IATA checklist to AMC. The complete IATA checklist can be found at <http://www.iata.org>.

Data Sources

AFI 11-2KC-135V3 states that every pound of excess fuel carried results in an increased fuel burn rate of 3 percent per hour in the KC-135.³⁰ This is the premise behind the Microsoft Excel-based Post-Mission Assessment Tool (PMAT) developed for this research project. PMAT determines excess fuel used on KC-135 missions (if any), calculates the fuel penalty for *ferrying* the fuel, and determines potential cost savings of targeted shutdown fuel levels.

In order to determine current levels of fuel consumption in the KC-135 fleet, calendar year 2006 post-mission summaries from AETC and AMC tanker units were compiled and evaluated using the PMAT. Some KC-10 data was also included for comparison. AMC summaries were provided by AMC Standardization and Evaluations, and AETC data were provided by Altus AFB, Oklahoma.

PMAT input data consisted of actual and planned (scheduled) KC-135 start fuel, fuel offloaded (total fuel delivered via in-flight refueling), shutdown fuel, and mission duration as shown in Table 2.

To better represent actual performance, missions that returned to home station with excess fuel due to maintenance issues or in-flight emergencies, in-flight refueling receiver cancellations, or special training requiring a higher shutdown fuel were removed from consideration.

Post-Mission Assessment

Based on post-mission summary data, the PMAT determines which missions were flown with excessive fuel for mission requirements (assuming a targeted shutdown fuel of 15,000, 20,000, or 25,000 pounds), derives a dollar cost of ferrying the excess fuel at \$2.50 per gallon, and calculates the number of fully loaded KC-135s the excess fuel represents. The model assumes 10,718 pounds per hour fuel burn rate which was obtained from Air Force Pamphlet 10-1403, *Air Mobility Planning Factors*.³¹ The PMAT offers a tool for planners to make rapid fuel load calculations that can be used as a starting point for mission

	Checklist Item	Response
1.1	Is your airline schedule built for maximum efficiency?	Yes/No (comments)
2.5	Are your dispatchers adding fuel for ad hoc reasons?	Yes/No (comments)
2.6	Do you have a well-defined and clear fuel plan?	Yes/No (comments)
2.7	Do you have a recommended arrival fuel for each airport over which dispatchers and pilots should look for opportunities?	Yes/No (comments)
3.1	Are all of your pilots up to the same standard regarding fuel efficient flying? Do you train pilots and dispatchers on the policy?	Yes/No (comments)
3.2	Are crews trained on efficient FMS programming to cross check flight plan fuel and accuracy to manage the fuel in-flight?	Yes/No (comments)

Table 1. Sample IATA Fuel and Emission Efficiency Checklist

planning as well as identifies potential man-hour savings for logistics and aircraft maintenance personnel.

Results

A review of 702 McConnell AFB, Kansas, missions from May to October 2006 revealed the average planned shutdown fuel was 31,000 pounds, but the average actual shutdown fuel was 36,700 pounds. This was 18 percent greater than the mission planned shutdown and 45 to 110 percent more than the local requirement. Table 3 illustrates an estimate of the potential annual savings for McConnell AFB by transitioning to a targeted shutdown fuel.

Incorporating 1,461 AMC KC-135 missions from five operating bases yielded the estimated potential savings for AMC depicted in Table 4.

Based on this KC-135 research, the implications of transitioning from a standard ramp load to a targeted shutdown fuel for the Air Force are quite significant. Results indicated the penalty for ferrying excess fuel ranged from 10.2 to 14.8 million pounds. As such, KC-135s are burning approximately 1 percent of AMC's total annual fuel to do nothing more than carry extra gas. After consolidating AMC results with AETC data, PMAT estimated the potential Air Force KC-135 fuel savings shown in Table 5.

In addition to fuel cost savings, manpower represents another area of potential savings identified by this research. Ground refueling of a KC-135 requires one fuels specialist and two to

three aircraft maintenance personnel. The fueling process takes approximately 1 hour for every 27,000 pounds of fuel loaded. If aircraft were only loaded to meet mission requirements, the workload of KC-135 maintenance and logistics personnel could be significantly reduced. To better illustrate this point, 16 to 20 million pounds would not have been loaded onto aircraft had the AETC missions in this study been planned using a targeted shutdown fuel. This equates to a savings of 1,800 to 2,200 man hours. Since the average AMC shutdown fuel is greater than the AETC mission average, potential man hour savings are significantly higher for AMC. The manpower benefits from a targeted shutdown fuel plan are a step in the right direction towards addressing the effects of pending personnel cuts.

Optimized Mission Planning

Based partially on the results of this article, AMC directed the immediate elimination of the standard ramp fuel practice. In order to comply with this guidance, KC-135 units should transition to an airline industry model of using dispatched mission planning, and loading only the fuel required for mission accomplishment. This should reduce the amount of fuel carried and eliminate excess consumption associated with ferrying unneeded fuel. The proposed model incorporates multiple aspects of the KC-135 mission planning and execution process including mission support, dispatch planning, and post-mission analysis.

Squadron	Month-Year							
Name	Fuel at Engine Start		Air Refuel Onload/Offload		Shutdown Fuel		Mission Duration	
Date or Call Sign	Actual	Scheduled	Actual	Scheduled	Actual	Scheduled	Actual	Scheduled
Day-Month-Year	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2. PMAT Data Entry Sheet

Estimate for 1 Year	Pounds	Gallons	Cost	KC-135s*
15K Shutdown	5,231,489.86	780,819.38	\$1,952,048.45	26.16
20K Shutdown	4,434,820.22	661,913.47	\$1,654,783.66	22.17
25K Shutdown	3,612,322.98	539,152.68	\$1,347,881.71	18.06

*Indicates number of fully loaded KC-135s

Table 3. McConnell Fuel Savings

Estimate for 1 Year	Pounds	Gallons	Cost	200K/lbs*
15K Shutdown	14,891,383.03	2,222,594.48	\$5,556,486.20	74.46
20K Shutdown	12,567,795.17	1,875,790.32	\$4,689,475.81	62.84
25K Shutdown	10,223,812.12	1,525,942.11	\$3,814,855.27	51.12

*Indicates the number of fully-loaded KC-135s (200K lbs) the savings equal

Table 4. AMC Potential Savings

Estimate for 1 Year	Pounds	Gallons	Cost	200K/lbs
15K Shutdown	22,537,299.29	3,363,776.01	\$8,409,440.03	112.69
20K Shutdown	18,118,782.35	2,704,295.87	\$6,760,739.68	90.59
25K Shutdown	13,586,691.53	2,027,864.41	\$5,069,661.02	67.93

Reflects the consolidation of AETC and AMC estimated fuel savings—does not include ANG/AFRES aircraft

Table 5. Air Force Potential Savings

Ground Support Functions

Using an industry model, fuel would not be loaded onto the aircraft until the last possible moment. At a specified time (for example, 6 hours prior to aircrew show time), maintenance personnel would begin to accomplish all required preflight activities. This aircraft generation process requires one fuel personnel and a crew of two to three maintenance personnel, as well as a fuel truck to pump fuel. When the required mission fuel quantity has been finalized by the dispatch center, fuel then begins loading onto the aircraft. The fuel *finalization* process is the key component of a successful mission fuel reduction effort. Several hours prior to a mission, the dispatch center would calculate the *planned fuel* and establish a target fuel load for the maintenance personnel to use for planning. Subsequently, the assigned aircraft commander would verify that the proposed mission fuel is adequate to meet requirements after a careful assessment of the flight plan, prevailing and forecasted weather, and any unique receiver aircraft requirements. Then the final just-in-time fuel is loaded onto the aircraft.

Service management tools such as Gantt project charts could be useful when considering the generation of aircraft as a project and mapping out the fueling process from the time the aircraft lands to the scheduled departure time of the aircraft's subsequent

by all AMC units. Accurate mapping of aircraft generation processes could result in not only a decrease in aircraft fuel consumption but also a reduction in man hours as well as ground support equipment and vehicle fuel usage. Using these service management tools could provide the added benefit of enabling an efficiency assessment of individual processes. This would allow managers to quantify the amount of time required to accomplish aircraft generation, what percentage of time workers actually contribute value to the service, and how much system capacity is utilized. This application of lean principles would help determine what events could be combined or possibly eliminated.

Dispatch Operations

Under a central dispatch system, aircraft would be fueled to the proposed fuel load beginning 2 hours prior to aircrew show time (unless more time is needed to accommodate larger fuel loads). Aircrews would arrive approximately 4 hours prior to takeoff, review the mission plan, and confirm the target fuel load is appropriate to meet mission needs. At 3 hours prior to takeoff, any final adjustments to fuel load must be made to allow for JIT fueling.

Following the mission, all crews would file post-mission summaries with central dispatchers. With the aircraft commander

While \$28M is a significant amount of money, initial indications show the possibility of savings in excess of \$160M per year through the application of major fuel efficiency initiatives across the command.

mission. Network diagrams and facility layouts could also be used for flight line prepositioning of required aircraft generation and fueling equipment. Gantt charts could be helpful in determining the necessary timing of individual aircraft pre- and post-flight actions to include mission development, fuel allocation, and action points necessary for the fueling of aircraft based on a scheduled departure time.³²

Quite often fuel trucks and fueling crews move from aircraft to aircraft in order of departure priority which is not necessarily based on aircraft parking location. Network diagrams could be developed to identify the shortest routes for fuel trucks to travel from transportation storage locations to their assigned aircraft parking locations. These distances can range from as short as several hundred yards to a few miles depending on where aircraft are parked following a mission. Network diagrams could also be used to identify optimum locations for prepositioning aircraft generation and fueling equipment to help further expedite the process. By mapping key paths using Clarke-Wright Algorithms, the shortest distances could be determined daily.³³ This could be useful in several ways, such as mapping out optimum route paths to support aircraft already assigned to particular parking locations or by determining the optimal parking location for an arriving aircraft in more advanced planning.

Potential benefits that could be achieved are increases in both manpower and equipment efficiency through decreases in the time required to accomplish dispatched fueling system tasks. Following a successful demonstration, the KC-135 dispatch system could become the aircraft generation model to be used

present, a central dispatch representative would load mission summary information into the PMAT to assess mission efficiency, note any mission deviations, gather feedback on the mission plan, and determine necessary changes to fuel loads for subsequent missions.

Aircrew Training

The next step in improving fuel efficiency is the development of an aircrew training syllabus that would encompass the new mission planning procedures. Crews should be trained during initial qualification to accomplish mission planning using the central dispatch mission process and targeted fuel loads. A scenario-based KC-135 mission planner course should also be developed to create *energy awareness*. This course should expose aircrews to mission tasking, planning, and fuel allocation. Following a simulation of the plan, aircrews should conduct a review of the mission using PMAT to determine if the mission could have been planned or flown in a more efficient manner.

Development of AMC Energy Division

AMC should consider the development of an energy division consisting of operations and logistics personnel whose primary tasks consist of monitoring fuel consumption rates and continuously exploring industry fuel savings practices. This office would develop a briefing consisting of industry best practices and then travel to each AMC unit to discuss issues with aircrews and logistics personnel in a combined forum. A portion

of their briefing should provide the command's perspective on AMC Pamphlet 11-3. When they travel to each base, they would review and observe the dispatch process as well as survey aircrews to determine how well energy initiatives are being applied. This approach complements the lean principle of the continual pursuit of *Perfection*.

Culture Change

The prevailing theme of site visits to several commercial air carriers is that successful fuel savings is a cultural issue. Fostering cultural change is not easy; however, there are some lessons that can be learned. At United, increasing fuel efficiency was taken so seriously by the company that they placed one of their most senior and experienced pilots in charge of the effort as Manager of Operational Efficiency. This gave significant credibility to the effort. They also focused on training their pilots and dispatchers together which helped them to develop and maintain efficiency gains.


Conclusion

The focus of this research was on increasing KC-135 fuel efficiency through mission planning enhanced by lean principles. By implementing targeted fuel loads and a central dispatch system, significant fuel savings are possible. The concepts and findings addressed could be tailored to various AMC aircraft mission processes. AMC is the largest consumer of fuel in the DoD, and flew over 142,000 sorties in 2005. "If \$200 were saved on every sortie, then the command could save over \$28M per year. While \$28M is a significant amount of money, initial indications show the possibility of savings in excess of \$160M per year through the application of major fuel efficiency initiatives across the command."³⁴

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If I had to sum up in a word what makes a good manager, I'd say decisiveness. You can use the fanciest computers to gather the numbers, but in the end you have to set a timetable and act.

—Lido Anthony (Lee) Iacocca

If opportunity doesn't knock, build a door.

—Milton Berle

Meeting the Army's Equipping Challenge

Jim Campbell, Colonel, USA

Introduction

Today's Army faces different challenges than it did in previous years. Given the Army's high operating tempo (OPTEMPO), its transformation to modular design, and potential contingency requirements, the Army must ask itself if it is ready to meet its equipping goals for today and for the future. This article explores the United States Army's current equipping strategy, and suggests the modifications needed to help create conditions and metrics to assess current equipment requirements as well as requirements for the future. First, it would be beneficial for the Army to modify readiness assessments of equipment required for mission accomplishment, and to develop metrics that more accurately reflect actual mission essential needs (including unit status report [USR] methodology). Second, a modified program similar to the Army Prepositioned Stock (APS) program is needed that is capable of rotational operations to facilitate the use of prepositioned equipment in current and future contingency operations. Finally, increased budgetary allocations specifically tied to achieving equipping strategies with improved acquisition programs and increased efficiency of the US industrial base will potentially increase the amount of military specific equipment available for use by soldiers. Alone, these measures will have a minor impact on the current situation, but taken collectively they provide a potential solution to overcome the current equipping dilemma facing the Army.

The recently adopted Army Force Generation (ARFORGEN) model combines equipment transfers, new production, and a *validated* reduction of modified table of equipment (MTOE) authorizations to meet readiness and mission requirements. The Army is not meeting its equipping requirements with new equipment production or procurement. Therefore, a large percentage of equipment is being transferred between units as they

cycle through deployment windows. This equipment shuffle strategy does not equal sustained readiness. Stripping units of MTOE equipment during deployments to fill shortages in another unit merely delays fixing the problem. It does not leave commanders or soldiers with the confidence that they will have equipment upon redeployment to train and improve unit readiness for the next mission. Likewise, a reduction of authorized equipment should not be the optimal solution. An arbitrary percentage of fill does not provide equipment critical for readiness, and further diminishes a commander's confidence that he will get the right equipment in sufficient quantities required for training or mission accomplishment. Nevertheless, these initiatives may be the only way the Army can continue this period of high OPTEMPO until more funding and quicker procurement capabilities are available.

We need to change the way the Army approaches readiness. A focused effort to determine unit requirements; specifically, what is needed to achieve readiness and training for contingency operations and deployments is the first step in this process. Army MTOEs are designed to provide the



equipment and personnel required to accomplish a broad scope of assigned missions. These authorization documents are focused on large scale operations conducted continuously over a 24-hour period. They include the operational, logistical and administrative tools necessary to sustain full scale combat operations. While absolutely essential for forced entry and initial combat operations, they may not be appropriate for other types of missions, such as humanitarian, peace enforcement, other types of stability operations and the current rotational environment to support the Global War on Terror (GWOT) in Southwest Asia. Taking a new approach in determining what a unit requires to train and prepare for the most likely deployment scenarios will allow the Army to reallocate equipment and achieve efficiencies without taking risk in operational capability and readiness.

	AOE	Modular MTOE
.50 Cal MG	277	865
M240B MG	372	563
TOW	180	112
LRAS	0	48
105MM How	54	64
120MM Mortar	0	48
HMMWV	1,862	3,349
Ambulance	61	178
FMTV	843	1,343
HEMTT	214	323
LHS	0	150
Apache	72	48
Kiowa Warrior	32	60
Chinook	48	24
TUAV	0	4

Table 1. 101st Airborne Division Equipment Changes with Modular Design

Article Acronyms

AERC – Army Equipping and Reuse Conference
AFSC – Army Field Support Command
AMC – Army Materiel Command
APS – Army Prepositioned Stock
AR – Army Requisition
ARFORGEN – Army Force Generation
CFLCC – Combined Force Land Component Command
CONUS – Continental United States
CRS – Congressional Research Service
DoD – Department of Defense
FOB – Forward Operating Base
GDP – Gross Domestic Product
GAO – General Accountability Office
GWOT – Global War on Terror
JRAC – Joint Rapid Acquisition Cell
LBE – Left Behind Equipment
MEEL – Mission Essential Equipment Lists
MTOE – Modified Table of Equipment
OEF – Operation Enduring Freedom
OIF – Operation Iraqi Freedom
OPTEMPO – Operating Tempo
PCTEF – Percent Effective
QDR – Quadrennial Defense Review
REF – Rapid Equipping Force
RFI – Rapid Fielding Initiative
USR – Unit Status Report

Another potential solution to the Army's equipping challenge is a modified and refocused effort to use prepositioned resources. A majority of the original APS assets for Southwest Asia were consumed by initial operations in Iraq. While the equipment in the APS fleet was used to support subsequent deployments and operations, there have been recent efforts to rebuild the APS fleet in Southwest Asia to prepare for future requirements. A program similar to APS could be integrated to support the current operations in Afghanistan and Iraq to provide a baseline equipment pool for use in sector as well as to reduce recurring equipping requirements for units preparing to deploy and to eliminate the strain on deploying forces to move equipment via strategic lift.

The third recommendation to improve the Army's equipping strategy is to increase funding and improve the production and procurement of materiel. The fiscal year (FY) 2007 Army budget estimation is \$111.8B with \$24.7B for procurement.¹ It is questionable whether this budget allocation for equipment procurement is enough to meet the full spectrum of demands of the Army. While we cannot afford to decrease the amount of money allocated to support current combat operations, we also cannot continue to neglect equipping forces to prepare them for deployment to Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF), force development and transformation, or other contingency foci.

The Army's challenge to fully outfit its units to facilitate readiness and training for deployment and contingency operations has been exacerbated by fighting a war while conducting major force transformation. The ARFORGEN process does provide a temporary solution, but also delays fixing the problem. A more aggressive equipping strategy is necessary in the short term to ensure the Army can meet the current and other unforeseen challenges it will face. Equipping the force is essential to set the conditions for commanders and soldiers to prepare for these missions. While no guarantee for success, the recommendations offered in this article can provide potential solutions to overcome the current equipping challenge in the Army.

The Current Environment: The Army Equipping Strategy

The 2006 Quadrennial Defense Review (QDR) identifies the requirement to reorganize and equip 281 Army modular brigades (active and reserve component).² At varying stages of this transformation process, units are finding that the new design of their organizations requires more equipment than previously authorized and, in many cases, new technology to improve lethality and battle space dominance. To illustrate this point, the 101st Airborne Division's equipment requirements increased up to four times or more for certain end items in 2004 when units began moving toward the modular design (see Table 1 for an example of equipment changes).

The Army equipping strategy, as defined in the 2006 Army Posture Statement, identifies maintaining funding support for current equipment modernization programs as one of the underlying principles to achieve modularity and remain relevant for future requirements.³ While this measure addresses modernization, it does not specifically address current shortfalls due to a rise in requirements from OIF and OEF, or the addition

of equipment based on the modular design. The Army does address these equipping requirements by stating that full funding of the 2007 Presidential Budget is required to support wartime demands and the Army equipping initiatives.⁴

Sponsored by the Secretary of the Army for Acquisition, Logistics and Technology, RAND Corporation conducted a study on equipment availability and mission accomplishment. While specifically oriented towards availability due to maintenance or equipment damage, the report concluded that equipment availability had a significant impact on unit effectiveness during combat.⁵ Although this study's conclusions are not specifically tied to equipping per se, they do provide additional support to the necessity of equipping our units to make them more agile, lethal, and capable to meet current and future operational requirements.

Realizing the necessity to equip the force to meet mission requirements, the Army is going through the process of developing specific initiatives to meet the current equipping challenge. During an equipping strategy brief to the Army War College in 2006, a briefer from the Army G8 provided the equipping priority list where transforming forces, APS, and non-deploying forces fall into the fourth priority and below.⁶ Therefore, there are areas receiving higher priority for equipment, which leads to less equipment to achieve transformation to the modular force and its associated readiness levels. This priority system will create an environment of tiered readiness until enough materiel is produced and procured to meet existing shortages. Reports from the Government Accountability Office (GAO), analysis from RAND and other agencies, as well as Army conferences, have been used to determine alternatives. In June 2006, the Army G8 hosted the semiannual Army Equipping and Reuse Conference (AERC). By design, the AERC charter is to accomplish the following to support the Army equipping strategy:

- Determine a methodology to use all available Army equipment
- Determine the total quantity of key systems required to support transformation
- Determine the dollar value to resource transformation
- Establish reuse as a source of supply to create equipping solutions
- Develop integrated fielding plans, reuse, distribution, reset, and retrograde equipping instructions⁷

In response to study recommendations, senior Army staff meetings, and existing resource constraints, the ARFORGEN program was adopted as an interim strategy to maintain the Army's ability to execute its current contingency requirements. Putting it into perspective from one Army source, "the new strategic

context of continuous operations renders obsolete the old Army readiness paradigm of *all ready, all the time*."⁸ Basically, ARFORGEN is a new approach to readiness which creates varying degrees of preparedness on a cyclical basis to meet known deployment requirements. The ARFORGEN methodology is based on a 1 to 3 ratio of deployment to home stationing goal that is not achievable based on current mission requirements and will continue to make equipping a challenge for those units that are not in a deployment window. Stating directly from Addendum E of the Army Posture Statement:

The ARFORGEN process creates operational readiness cycles where individual units increase their readiness over time, culminating in full mission readiness and availability to deploy. Manning, equipping, resourcing, and training processes are synchronized to the ARFORGEN process. To achieve the readiness progression required by operational readiness cycles, units transition through three ARFORGEN-defined readiness pools.⁹

With units at varying degrees of readiness and with current operational requirements in Southwest Asia, it is questionable whether the Army can continue with transformation to the modular design and still be ready to provide significant forces for another contingency if required. Figure 1 provides a view of the ARFORGEN model and implications of force readiness levels.

Because of competing demands for equipment, ARFORGEN is an interim strategy that has been adopted until the Army can achieve its equipping goals. This bridging strategy will use a combination of equipping units to less than MTOE authorizations, use of a force feasibility review,¹⁰ and left behind equipment (LBE) transfers.¹¹ Using this methodology, the Army will continue to face critical shortages of equipment and materiel required to achieve the modular force design and prepare for contingency operations outside of Southwest Asia. Using this guidance, the planned sourcing for equipping units preparing

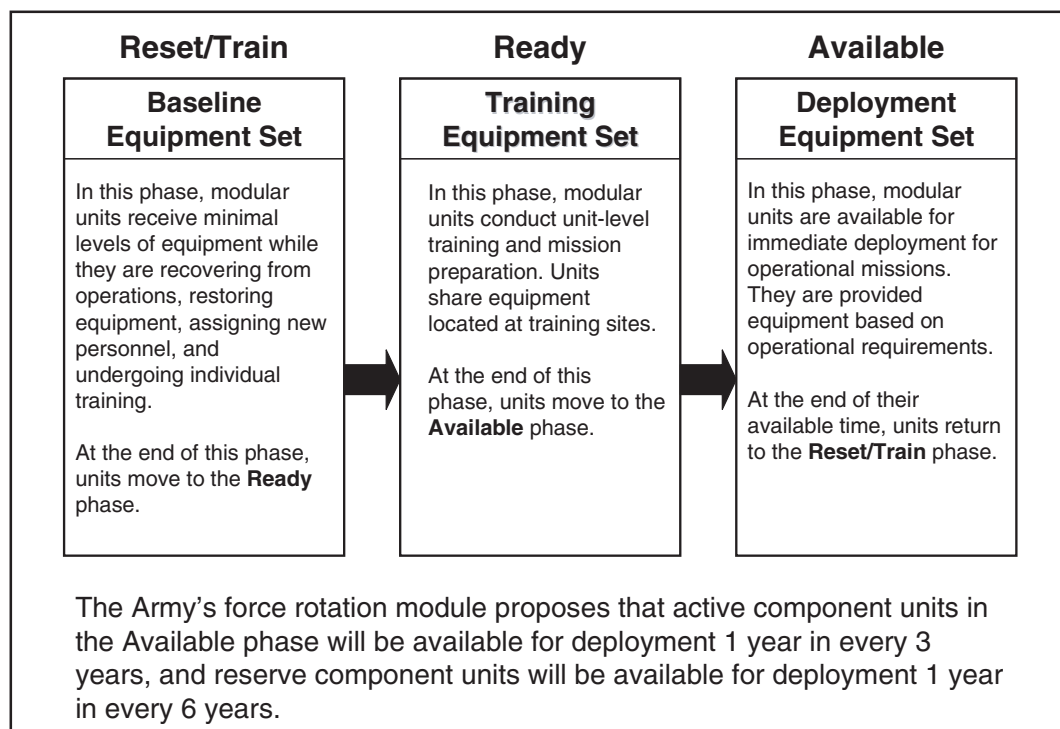


Figure 1. Force Rotation and Equipping Phases

to return to combat in Southwest Asia includes transfers from units already deployed, new production, and redistribution of excess. Whether all these items arrive before critical training gates is of the most benefit is questionable.

For the purpose of illustration, the 101st Airborne Division's recent redeployment from Iraq and reconstitution efforts reflects an example of the equipping challenge. During the division's deployment, over 3,100 vehicles were transferred to continental United States (CONUS) forces, Combined Force Land Component Command (CFLCC) for use in Southwest Asia, and Army Materiel Command (AMC) refurbishment programs.¹² During the transformation process to the modular design, units in the 101st Airborne Division went from an S1 to S4 rating for equipment on hand. After the transfer of equipment (during its most recent deployment), unit readiness due to equipment on hand fell further, leaving units with numerous critical shortages identified as essential in training soldiers and units to prepare them for the next deployment.¹³

With a few months of training time remaining prior to deployment for another mission in Southwest Asia, the soldiers and units preparing to deploy into combat once again will lose precious time available to hone their skills. Although specifically addressing one unit, these circumstances replicate the ARFORGEN process which does not provide an optimal situation to prepare for real world contingency deployments and does not provide the readiness level commensurate with the task at hand.

Readiness Assessments

The majority of today's forces are inadequately equipped in accordance with their MTOE authorizations. Chapter 5 of Army Regulation (AR) 220-1 directs units to calculate their equipment on-hand ratings by comparing a unit's fill of equipment to its wartime requirements.¹⁴ Many of our units are reporting S4 (the lowest readiness rating for equipment possible in a unit) prior to their deployments. Shortages of vehicles, radios, and weapons directly affect a unit's ability to train for its mission to conduct large scale contingency operations. Many below-the-line shortages, while not seen as a direct impact on readiness, do affect the unit's ability to continue operations for long durations. Tool sets, diagnostic equipment, slings, power generation, and other items that are not seen as key pieces of equipment for direct combat operations have an impact on the sustainment of the force during long scale operations, such as our units experience today.

In a 1971 GAO report, the authors stated the Army had a poor unit equipment reporting system and indicated it needed to improve the process for identifying essential equipment needs.¹⁵ The same trend resurfaced in a 1999 report. In this subsequent report, the GAO indicated the USR was not comprehensive enough and recommended commanders specifically identify operational impact of equipment shortages.¹⁶ Many commanders still consider the USR as a report card. We need to shift this focus to more tangible readiness issues instead of a percentage of equipment fill. The Army has made progress in this direction by integrating the percent effective (PCTEF) rating portion of the USR for deploying and deployed forces. The PCTEF rating is a Joint requirement and measures a unit's ability to accomplish its specific mission or operational deployment.¹⁷

Based on the most likely operational area of employment, it would be more beneficial to refocus the readiness reporting system to accurately reflect the mission essential equipment

required for the mission a unit will most likely receive. While this appears to be part of the objective of ARFORGEN, there will be equipping delays until a unit is in its deployment window, which postpones valuable individual and team training time to prepare for the range of missions assigned. Commanders should address equipping requirements with specificity of the mission, range or scope of operations, timeframe required and required capability, all tied to a specific purpose. We should also look at redundant capabilities and equipment tied to *less likely* missions so that planning can include the resources required to achieve mission success before opting to choose certain courses of action. While this may result in some duplicity of effort for reporting, it will ultimately provide the Army with a more accurate picture of critical equipping needs and will allow our senior leaders to prioritize the equipping effort.

Taking this reporting methodology one step further, criteria such as mission essential and mission enhancing must be applied to ensure we allocate the right equipment in sufficient quantities to positively influence mission accomplishment without allocating too much equipment, thereby reducing training and mission preparedness in other units. The specific missions assigned to units operating in Southwest Asia are easier to address based on historical reference and trends from commanders and soldiers that have operated in the area. Assessing needs based on other threats or operational environments are not as easily defined and will require more latitude due to the uncertainty of the enemy and the operational environment. Nevertheless, with new guidelines to address readiness for the next mission, commanders can more accurately identify the shortages that affect the training and readiness of their soldiers and can provide the Army with the *no-kidding* bottom line requirements to adequately equip the force.

Right Sizing Equipment Requirements for OIF, OEF, and a Restructured Army Prepositioned Stocks-Like System

The Army Prepositioned Stocks (APS) program supports the national military strategy by prepositioning critical warfighting stocks in strategic locations worldwide to reduce deployment response times for an expeditionary and transforming Army. Prior to OIF, the core of the program was six brigade sets—two afloat and four ashore (one in Europe, one in Korea, and two in Southwest Asia). APS remains a critical component of Army power projection.¹⁸

The APS program is vital to the rapid deployment and employment of ground forces around the world. Managed by the Army Field Support Command (AFSC) component of the Army Materiel Command (AMC), equipment and supply sets are built to support Army ground combat forces to enable the rapid deployment of personnel (primarily) when the situation warrants boots on the ground without the time to deploy unit equipment. Upon such deployments, APS equipment is then issued to units for use in initial entry and contingency operations.

During the execution of OIF (rotations I through III), the Army expended a great deal of its materiel in APS sets to equip and sustain units operating in Iraq. The APS program deteriorated to the point that \$248M was specifically set aside by Congress to reconstitute the APS-5 set in Kuwait.¹⁹ The use of APS equipment to support combat operations was essential to fill capability gaps and continues in various areas to provide capability that would

otherwise not exist. Expanding this concept, we need a more focused effort on the equipping strategy used for forces engaged in OIF and OEF, and enforcement of the right amount of materiel to support soldiers in the fight.

An Army strategic studies paper, “The Army Prepositioned Stocks Program: Are We There Yet?” validates the need for APS programs and offers suggestions to ensure its continued relevance for the future by recommending continuous evolution to support GWOT, transformation, and prepositioning of more combat support and service support equipment.²⁰ Additional benefits could be achieved by modifying the program to create a support structure specifically for GWOT operations in Southwest Asia. There are already satellite programs in Kuwait and Iraq that conduct refurbishment, support, and some reconstitution of equipment for deployed forces. Using the existing infrastructure and adding personnel, AMC could provide a rotational support structure specifically tied to equipment requirements in Iraq and Afghanistan.

Without degrading operational capability, the amount of equipment currently in Iraq can be significantly decreased. While forces currently in sector have begun the process of excess elimination, there is much more that can be done. In today’s environment, Level I armor vehicles are required to conduct *off-*

submission of mission essential equipment lists (MEEL). Completed by both the current and deploying units, these lists are intended to identify the equipment required to operate in the specific sector assigned. Inevitably, there are differences between commands on the preferred weapons, vehicles, and optics, of choice to execute the mission. It would be more beneficial for all involved to establish a baseline authorization document for units operating in theater and then to equip the units accordingly. Unique or emerging technology can easily be addressed during subsequent deployments without revisiting the entire equipment list every year. Accomplishing this small feat would set the stage for the adoption of an effective equipment rotation program for units operating in Southwest Asia.

This conceptual program entails the development and improvement of the right set of equipment based on mission requirements, and facilitates its issue to units operating in sector. Simultaneously, an identical equipment set (or sets) would be staged, maintained or refurbished in order to prepare for future rotations. Based on OPTEMPO, wear rates and recommendations by senior maintenance experts, these sets would rotate in a similar fashion as the soldiers and units currently conducting operations in sector.

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forward operating base (FOB) operations; yet there are significant amounts of Level II and *soft-skinned* vehicles being used for administrative and convenience movements. Options that include walking, commercial vehicles and buses, and a motor pool type operation to share the vehicles required for on-FOB administrative type tasks would reduce the amount of nonmission essential vehicles and produce more equipment for return to the CONUS and enrollment in refurbishment programs and subsequent issue to meet training and readiness requirements in the Army. There have been significant efforts to reduce the equipment footprint in Iraq and return items to CONUS for refurbishment, but as many as 7,000-plus vehicles still remain in theater waiting for return.²¹ Reliance on contractors to deliver a large quantity of sustainment stocks supports a reduction of medium to heavy platforms and their return for refurbishment and reissue. An increased use of aerial delivery by intratheater air assets will further reduce the requirement for large numbers of tactical convoys, and subsequently reduce the number of vehicles required for sustainment operations.

Prior to each unit’s deployment into Iraq, leaders’ reconnaissance trips, communications with forces currently engaged, and conferences are held to help prepare the units for their deployment. Part of this process is a validation and

In addition to providing equipment needed for the current fight, this concept would accomplish seven objectives.

- Better maintenance and operational rates for equipment required to support the fight
- Decreased transportation costs to ship unit equipment to Southwest Asia
- Improved supply stocks to support operations in the specific environment where soldiers are currently focused
- Known equipment types and density requirements for operations in Iraq and Afghanistan
- Reduced requirements to replace fatigued equipment
- Increased or more efficient ability to install upgrades on equipment without impacting operations in sector
- More equipment available off the assembly line or from refurbishment centers for issue to fill training and readiness requirements by nondeployed forces

Increased Budgetary Allocations and Improved Acquisition

Historically, the Army has been under resourced—and it is a fact that the decade preceding the attacks of September 11, 2001 was no

exception. Army investment accounts were under funded by approximately \$100B, and 500,000 soldiers were reduced from total Army end strength. There was approximately \$56B in equipment shortages at the opening of the ground campaign in Iraq in the spring of 2003.²²

Based on the December 2006 Congressional Research Service (CRS) Report, the Army would need \$17.1B in FY07 to conduct equipment reset, another \$12B to \$13B during the conflict and beyond to continue reset efforts, and over \$41B to meet current equipment shortages.²³ The Army's budget allocation for FY06 was \$96.8B and is expected to be \$111.8B for FY07.²⁴ The Army's allocation for FY07 procurement of equipment is \$24.7B.²⁵ This allocation of funds is not adequate to meet the requirements to continue operations in Southwest Asia, transform to the modular force, and prepare for future contingency requirements. Congressional supplemental dollars are generally targeted to continue the war effort, and provide little for research and development programs or equipment procurement to continue transformation or improve readiness for units that are not deployed.

There is no doubt we are a military at war, but are we a nation at war? The percentage of our nation's Gross Domestic Product (GDP) and output of consumer goods compared to other times of war or conflict suggests we are not a nation at war. Table 2 provides a comparative view of expenditures of GDP for defense during varying times since World War II.²⁶

The trend suggests that the percent of GDP designated for defense spending during time of crisis is directly related to perceived or real threat to our national security or existence. While this may be an unfair assessment, these numbers could be interpreted to indicate that our government leaders and the American people are no longer willing to expend the dollars necessary to provide the materiel needed to adequately sustain the Armed Forces during its time of conflict as long as our way of life is not immediately or directly threatened.

Similarly, there has been a perceived deterioration in the military-industrial complex since the end of the Cold War.²⁷ Successful businesses operate based on supply, demand, and profit—and not necessarily in that order. While profitable for major weapons systems such as ships, aircraft, and tanks, the production of other items, unless they have a commercial benefit, put a business at risk.²⁸ In addition to funding, government subsidies or other incentives for businesses that have the capability to produce military specific equipment could be a significant catalyst to encouraging more production of items with little or no commercial value.

The specifications and special needs associated with many Army requirements (intelligence, surveillance and reconnaissance equipment, communications systems, night vision devices, and others) do not have a commensurate commercial application and require significant investment to build production capacity. Combined with marginal funding, the vendor base of legitimate businesses that can provide equipment based on the Army's demand schedule appears to be shrinking. For example, with an equipping budget of approximately \$136B

and slow materialization of the continuing resolution, one specific impact was the availability of 200 tactical satellite radio systems, but no money to purchase and provide them for units.²⁹

Vital to support contingency operations, the availability of these radios without the capability to buy and put them in the field led to shortages for mission requirements. The real concern is whether manufacturers will continue to produce military specific systems without the guarantee of sale and whether such equipment will be available when the money is allocated to procure them.

To ensure we have the right equipment that meets desired specifications, the Army began moving officers into the acquisition corps functional area in the early 1990s. Perceptions of their effectiveness differ, but the soldiers and civilians of the Army acquisition corps are our *frontline* units charged with ensuring we get the right equipment at the right time. Some changes may be beneficial to help them be more effective in accomplishing their mission. The Department of Defense (DoD) acquisition system has been under fire for many years. The Army acquisition system is no different. Studies from as far back as the early 1970s called for reform or change in one way or another. Significant programs to change the acquisition system were initiated in the mid-1990s by DoD, however, this is an ongoing process and additional change is still required.³⁰

An Army War College Strategic Studies paper, "A Review of Acquisition for Transformation, Modernization, and Recapitalization," indicates the Army acquisition process is too long to support all the current equipping needs.³¹ Equipment being used in Southwest Asia is being consumed at higher than anticipated rates due to destruction, battle damage, and high OPTEMPO. To remain relevant, the acquisition process must be more responsive to the needs of commanders and soldiers in the field and find innovative ways to make the procurement system faster. Programs such as rapid fielding initiative (RFI), rapid equipping force (REF) and the Joint rapid acquisition cell (JRAC) are movements in the right direction, but generally target emerging needs from units operating in combat or contingency operations and do not address the other side of the Army's equipping challenge (transformation, reconstitution, and others). Similar programs to get equipment through the procurement process and issued to units returning from operational deployments (in the midst of the transformation process or preparing for the next deployment) will benefit the whole Army and greatly assist in meeting the equipping requirements in today's environment.

While a major part of the equipping challenge our Army faces today is inadequate funding based on competing requirements, money alone is not the solution. The government does need to assess the allocation of funds to maintain the current OPTEMPO, but also needs to provide additional money to support equipping the force that is not directly engaged in contingency operations to support the GWOT. Additionally, there needs to be more participation of the military-industrial complex and other industries to provide the materiel necessary to continue supporting the soldiers in the fight and support Army transformation and the inevitable contingency operations in regions not yet realized. One could argue this should include a reduction of consumer luxury items to support national defense for the near term. Finally, a more concerted effort from the Army's acquisition experts is needed in order to find viable solutions

	World War II	Korea	Vietnam	GWOT
Year	1944	1953	1968	2006
GDP %	39.3%	14.5%	9.6%	4.1%

Table 2. Comparative Expenditures of GDP for Defense

that make the most out of the funds available to get equipment to soldiers in the fastest way possible.

Conclusions

Equipping the Army has never been an easy task and will continue to be a challenge. In the ever-changing global environment of current and emerging threats to our national security, it is essential that we remain a strong and flexible force to provide options for our nation's leaders. Army transformation is a critical step in this process and provides forces that are adaptive, flexible, and ready to meet the threats of today and tomorrow. However, to reap the benefits of a modular force, it must be adequately equipped to execute the mission.

In the current operational situation with units engaged in the full spectrum of contingency operations around the world, and the Army in the midst of transforming its formations, the competition for equipment is exceeding the budgetary and industrial output to meet all demands. To meet its Title 10 responsibility of equipping the force, the Army continues to engage in short term solutions that delay fixing the readiness issues that affect the units organized to conduct a wide range of military operations. The ARFORGEN approach of cyclical readiness is, in the author's opinion, an attempt to fix a symptom

from the full MTOE authorization assessment and concentrate on the equipment critical for their mission accomplishment. Simultaneously, a detailed review and validation of equipment required to support operations in Southwest Asia is needed to produce an authorization document of some type that does not require annual validation or rewrite by every unit that deploys. This would provide a clear target for critical equipment needs to meet the current threat, and in the case of units designated for other contingency operations the needs to confront emerging threats.

Supporting soldiers and operations in Southwest Asia is the most important equipping requirement today. Usage rates and consumption of equipment due to battle loss, damage, and fatigue do require replenishment; however, with an authorization document that addresses critical equipment needs, In the author's opinion, the Army can reduce the equipment footprint in theater. Once achieved, this effort would allow equipment to flow back to CONUS for refurbishment or to facilities in theater to be used to build and reconstitute a program similar to APS, which is specifically oriented towards sustaining OEF or OIF. While this program would have a significant cost in terms of money and materiel, it would provide long term benefits as described in this article.

Using a different approach to the problem and looking for alternative methods to achieve appropriate readiness levels, there are solutions available to help achieve a balance between readiness and training requirements, and continue to equip units currently involved in contingency operations.

without addressing the problem head on. This statement does not portend that our leadership is not trying to fix the equipping challenge. It does, however, warrant debate and alternatives that could provide possible solutions to the current equipping challenge.

This article was written in an attempt to provide options that may be part of the solution set to improving the equipping situation in the Army. There is no one, single area that will make the difference, and it will take a combination of solutions to overcome today's equipping challenge. A new perspective on readiness reporting, adapting an APS-like program into a solution for units currently operating in Southwest Asia and increased budget (dollars) specifically tied to procuring critical equipment shortages with matched industrial output, and quicker acquisition systems are three areas that could either provide a solution to the problem or at least start the dialog until a better solution is realized.

Real equipment requirements must be addressed first. Suspend or rewrite the unit status reporting regulations to address the mission essential equipment requirements based on the current missions that Army units are engaged in (or are most likely to be engaged in). Fashioned after the PCTEF assessment during actual deployment, this measure would allow commanders to get away

The December 2006 CRS Report on equipment requirements, as well as the 2006 and 2007 Army Posture Statements, support increasing the Army's budget for support equipment procurement. An increased allocation of money specifically tied to equipment procurement is required; however, it must be supported by an industrial base that can readily provide the materiel needed. The typical consumers' ability to purchase goods is no less restrictive than it was before the war. The demand and cost associated with producing plasma televisions is more lucrative than the production of enhanced armor (individual and vehicle) or indirect fire systems. In the author's opinion, although potentially socially unacceptable and politically unpalatable, we need a shift of focus by industry to produce the types of equipment necessary for the Army (and the DoD) to maintain its ability to prepare for the mission assigned. Therefore, we must find alternative means to produce the equipment required to fight and win our nation's wars. To be effective, it must be accomplished without competing directly with the consumer markets. In the author's opinion, the government could enact legislation that either provides incentives for the production of military specific items or reduces the production of consumer goods in order to increase the output of industry to support the US armed forces mission. To help overcome the production


challenge there is also a strong case to continue efforts to reform the defense acquisition system to improve responsiveness.

The range and magnitude of requirements facing the Army today are formidable. Taken in their individual context they would present a challenge. Fighting and sustaining a war for multiple years requires a constant effort to keep soldiers and units equipped. Reconstituting units after a major deployment is another significant venture and requires money, materiel, and time. Conducting a major transformation of the entire force is yet another daunting task that competes for the resources needed to effectively execute the changes in our new modular design. Collectively, these challenges have exacerbated the Army's equipping challenge and, without more money, will continue to affect readiness across the force.

Based on the range of requirements it faces today, the original question of whether the Army can meet its equipping goals is answered with caution. Given its budgetary allocations, cost of equipment replacement programs, industrial capacity, and the rate of equipment requirements and destruction, the easy answer is no. However, using a different approach to the problem and looking for alternative methods to achieve appropriate readiness levels, there are solutions available to help achieve a balance between readiness and training requirements, and continue to equip units currently involved in contingency operations. Achieving this balance will require innovation, hard decisions, commitment to a plan, and additional funding specifically focused on a detailed equipping strategy.

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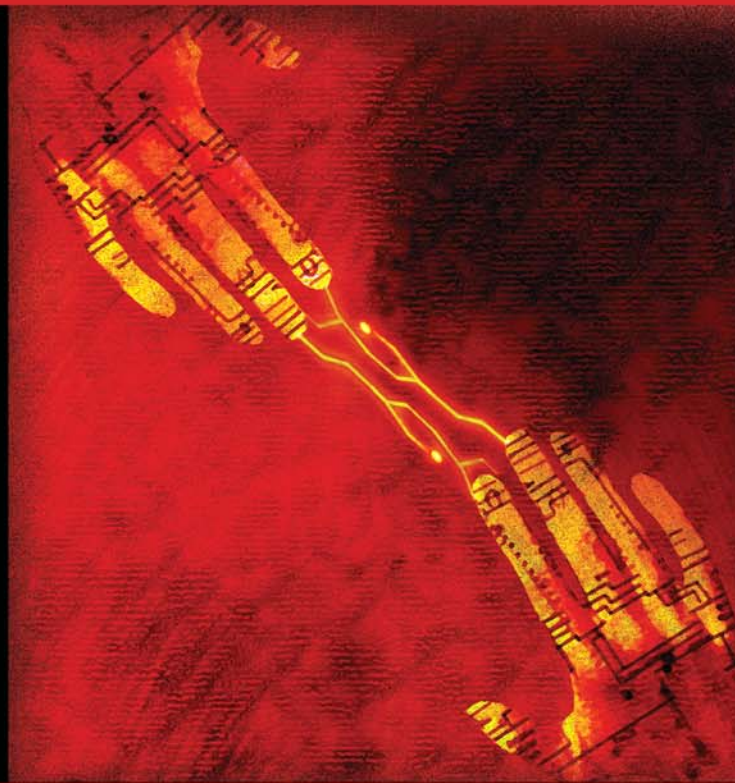
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EXPLORING THE HEART OF LOGISTICS

Bringing Logistics into the Laboratory: Developing a Team-Based Logistics Task

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Background

Organizations are facing increasing demands that accompany the ubiquitous change characteristic of contemporary work domains.^{1,2} To accommodate some of these changes, organizations implement work teams.^{3, 4, 5} Traditionally, the military has relied on teams of people to accomplish their missions. This is particularly evident within the realm of logistics. Military logistics involves ensuring that the right material elements of combat capability are delivered together at the proper location and time while in a configuration that is beneficial to the supported commander.⁶ United States Air Force logistics utilizes many distributed teams throughout the enterprise with the goal of transitioning from large, fixed organizational units to smaller, more agile units.^{7, 8} Logistics operations are increasingly complex as information exchanges are conducted across distributed information nodes at demanding operation tempo.^{9, 10} This is reflected in contemporary military logistics doctrine (such as sense and respond logistics, distributed adaptive logistics, and focused logistics) which emphasizes network-centric operations and adaptability as key determinants of logistics success in military operations.¹¹

The increased complexity and turbulent environments in which logistics teams are required to operate introduce novel requirements for team effectiveness. Past researchers have conceptualized team types along a continuum from simple to complex as determined by the performance contexts in which the team is required to operate.¹² Clearly, the logistics teams operating in today's warfare environment exist at the complex end of the continuum. Such teams often perform highly structured but dynamic tasks, share common goals, have specialized task requirements and distributed expertise, and have differentiated roles but coordinated patterns of interdependencies dictated by

task requirements.¹³ A key determinate of effectiveness in such teams is the ability of team members to integrate their individual efforts and balance their workflow interdependencies to changing situational demands. Moreover, adaptability as a performance capability of teams is critical to interdependent work teams and long-term team effectiveness.¹⁴

As with the overall logistics domain, the teams operating in the warfare environment are best viewed as an adaptive network where individual roles (nodes) and the links between them can be reconfigured or adapted to meet changing task demands. To achieve effective team performance, team members must develop appropriate knowledge and skills in order to comprehend the patterns of role exchange and the relation of differing network patterns to changing task demands.¹⁵ In order to examine such performance and determine if the appropriate knowledge and skills are being developed, we must adopt a process-oriented, developmental perspective and assess team performance under changing task demands.

Information managers, or knowledge workers, in logistic readiness centers dedicate many hours to collecting information worldwide; they analyze that information, then they redistribute the combined knowledge necessary for military planners to make informed decisions. This places human operators at the heart of logistics networks. However, technology solutions and sophisticated mathematical algorithms tend to be the focus of logistics research.^{16, 17} The success of these knowledge workers is dependent on distributed teams working collaboratively on a shared information space. Lessons learned from Operation Iraqi Freedom emphasize the importance of information exchange between logistics operators.¹⁸ Even where information is gathered, analyzed, and then acted upon at a base-wide scale, distributed teams are key to the success of the mission. Examples of base-size teams include the coordination of aircraft maintenance activities, sortie generation and logistics planning, and generalized aerial port operations. Effective collaboration is a key facilitator amongst these distributed logistics teams.

Collaboration in a general sense refers to the cooperative exchange of information that may result in a novel product or idea.¹⁹ Modern day logistics operations often involve

Article Acronyms

CAPS - Computer-Based Aerial Port Simulation

ATOF - Air Terminal Operation Flight

GUI - Graphical User Interface

XML - Extensible Markup Language

interactions among coalition forces in joint operations, thus placing greater reliance on effective collaboration. One way that researchers can gain a better understanding of the factors that influence team collaboration and performance is to design experimental scenarios that require teams to work together on tasks requiring coordination, planning, and problem solving. Laboratory environments are increasingly being used to examine team performance.²⁰ However, the development of team-based laboratory scenarios is limited by potentially extracting the physical fidelity that facilitates generalization from the research scenario to the applied setting. Modern simulations, albeit at a high cost, can replicate many of the intricate details of operational settings and are often used in aviation domains. Unfortunately, financial concerns will preclude the development of many of these high-fidelity simulations. In contrast, the psychological²¹ or task-related (synthetic) fidelity²² of a laboratory scenario may provide a very viable alternative. Even simulations of very low physical fidelity can be useful in predicting performance when they are task relevant.²³ Researchers at the Cognitive Engineering Research on Team Tasks Laboratory^{24, 25} epitomize the development of team-based laboratory tasks. Their scenarios and tasks replicate the behaviors and skills represented in the real world domain.²⁶ Similarly, the present research involves a scenario with low physical fidelity yet high psychological and task-related fidelity.

Further increasing the psychological fidelity of the task, the Computer-Based Aerial Port Simulation (CAPS) scenario replicates the demands of the dynamic, unpredictable environment characteristic of warfare today. By injecting common disturbances that can occur in natural settings into the simulation and incorporating the assessment of the teams' adaptive behavior in response to such disturbances, the outcomes generated by the CAPS simulation provide increased generalizability to real world settings. When examining team collaboration, we must acknowledge that such coordination, planning, and problem solving often occurs in turbulent ever-changing environments, and therefore we must incorporate these aspects into our studies. A goal of such studies should be to provide novel situations that require adaptation and the display of a new skill set and strategies that culminate in a deeper understanding of the task and aid in future adaptive behavior.²⁷

Aerial Port Operations

Aerial port operations are an excellent research domain for this type of research. They provide researchers with team-level tasks that are naturally organized in a distributed team context. The behavior of successfully launching a sortie with the proper passengers and cargo represents a viable candidate for an objective performance measure to be assessed at the team level. At a general level, aerial port squadrons consist of five primary sections:

- Passenger services
- Fleet services
- Cargo services
- Ramp services
- Air terminal operation flight (ATOF)

Passenger services focuses on the in-processing, manifesting, loading, and unloading of passengers. Fleet services provides

for the loading of aircraft supplies, ordering and delivery of meals to the aircraft, and servicing of the aircraft. Cargo services are responsible for the in-processing, prioritization and sequencing of cargo. Ramp services' primary responsibility is for the uploading and downloading of cargo. ATOF represents the information broker for the entire aerial port. The ATOF section monitors all aerial port activities, ensuring that all the necessary activities are accomplished, and maintains constant communication networks with the other four sections. Aircraft requirements are passed down from ATOF to the other sections.

Aerial port squadrons are excellent candidates for empirical work on logistics collaboration. Like many other distributed logistics teams, they can be characterized as a virtual team. Virtual teams are defined as two or more individuals who do the following.

- Work interdependently
- Have and strive toward a common goal
- Use technology to interact²⁸

Aerial port squadrons involve several team members who possess unique sets of skills and conduct unique activities toward the shared goal of completing aircraft requirements in the time allotted. Furthermore, aerial port squadrons typically use technology (e-mail, phones, and radios) to communicate within the different sections during their operations. Thus, aerial ports represent one form of virtual team.

Computer-Based Aerial Port Simulation

A Java-based platform was designed to simulate an aerial port squadron. The platform, referred to as CAPS, consists of five different subject stations whose functions were described in the previous section (passenger services, fleet services, cargo services, ramp services, and ATOF). An experimenter station was also designed to allow for the scenarios to be loaded, the status of the subjects and the scenario to be tracked, and psychological assessments to be loaded and distributed to the different subjects.

The primary software components of interest are the individual client-side subject stations that are operating during the sessions. The challenge of the design of these components includes displaying real time information about activity on the flight line, as well as allowing the subjects to interact with the flight line. This required real-time interactions with software objects and manipulation of objects on the screen; therefore, the latest version of a client-side language was used (Java Standard Edition 5.0). Figure 1 displays an example of the general graphical user interface (GUI). (The present GUI represents the interface for the passenger services section).

To provide participants with a shared information space and communication capabilities, it was critical that a database be used for the storage, retrieval, and updating of information in a real time manner. It was desirable to have a database that was not of a proprietary nature, therefore MySQL was chosen. The tables are all initialized when the experimenter begins the experiment. Updating and retrieving of information are possible by all of the subject stations as well. A simple chat tool was designed to facilitate collaboration within the team. As shown in Figure 1, participants had direct access to chat windows with each of the other participants, as well as a general chat capability similar to a chat room. All of the messages are logged in a database for later

coding and analysis. The chat tool is remarkably similar to contemporary instant messenger systems, and as such, participants were expected to adapt to the system with relative ease. However, from the experimenter perspective, the chat feature records text outputs, timestamps each message, and records the sender and the receiver of the message. All of the chat information is written to an Excel spreadsheet at the conclusion of each session, allowing for the content of the chat data to be analyzed by the researchers with relative parsimony. Researchers have suggested that content-based analysis of team communications has been shown to be an effective way to assess team-level constructs.²⁹

CAPS Training Development

The Instructional System Design (ISD) model was used to develop the training materials for the simulation. Initially, the required outcomes of the training were determined by the developers of the experimental platform in accordance with the performance requirements inherent in each of the five individual subtasks within the CAPS scenario. These same individuals then developed a written outline of the information needed by each individual for success in each subtask. Next, this group designed and developed a series of computer generated slides which described and demonstrated individual task procedures (see Figure 2). These slides were coded in order to be displayed as a slideshow (approximately 10 minutes in length) at the beginning of the CAPS scenario.

The initial implementation of these training slides provided an opportunity for training evaluation. Five novices were recruited for an initial run-through of the task. Each novice was provided with a notepad and asked to list any questions, comments, or ideas that arose during the training slideshow and during the task. Each subject then reviewed the slides and attempted to perform

that subtask. Following a 15-minute performance period, all participants, task developers, and other observers engaged in a question and answer discussion session.

Through qualitative analysis (group discussion, review of written questions and comments, and direct elicitation of specific information from individuals), specific training issues or problems were highlighted. First, participants experienced a lack of understanding of the task procedures, which was due, in part, to slideshow design. Many slides had incorporated the use of links to other slides containing additional information, thus

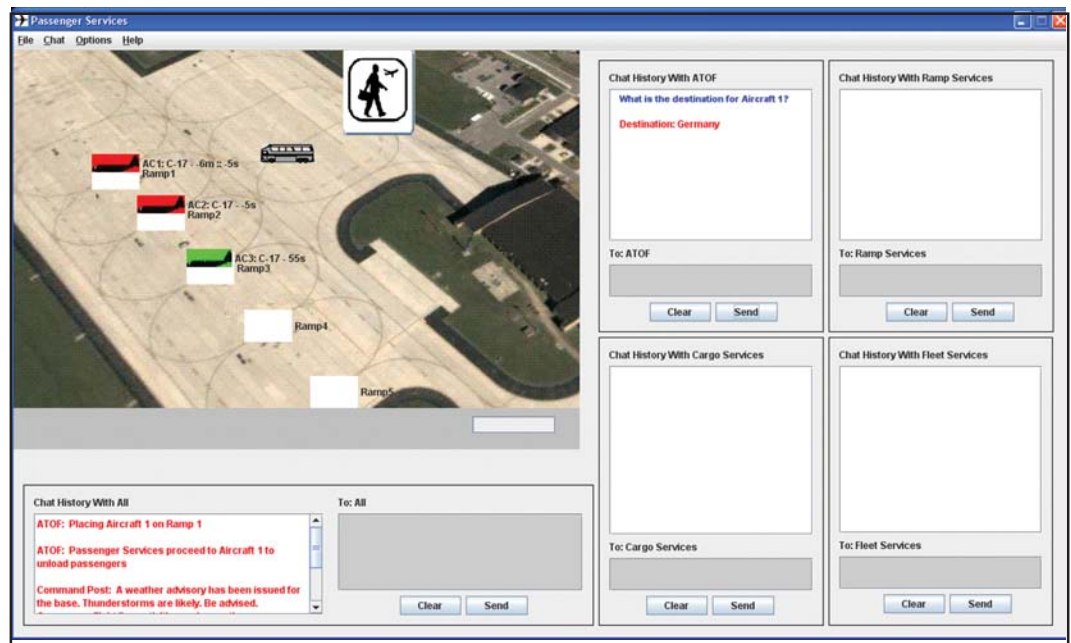


Figure 1. General CAPS GUI (Passenger Services Station Represented)

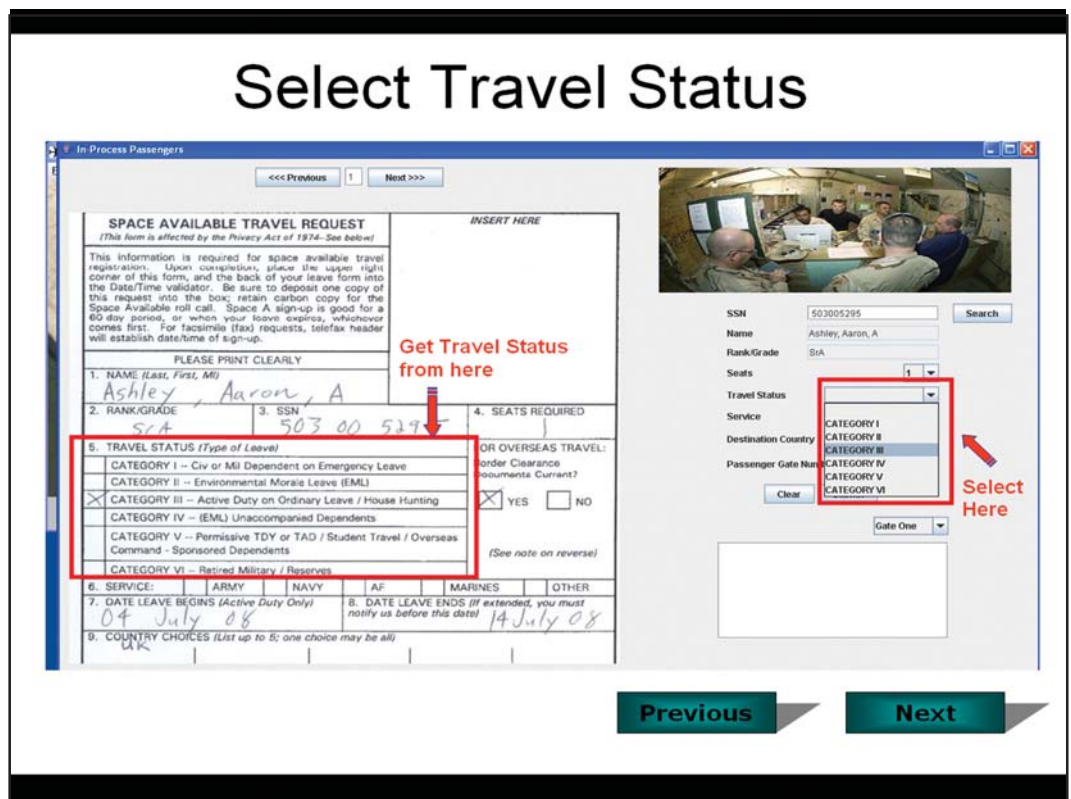


Figure 2. Sample Training Slide (Passenger Services Station Represented)

requiring the participants to select or click on the link in order to access the full gamut of information. Some participants failed to select one or more of these links and therefore missed important information. This problem was remedied by removing all links and displaying all slides in order so that the training slideshow exposed all individuals to the entire procedural information.

A second issue was the lack of a general understanding of how the individual tasks were related to the overall team task. This led to the development of a general introduction to the task. This introduction was designed as a set of preliminary slides which described an overview of the task at the macro level. These slides were incorporated into the beginning of the slideshow for each subtask station. Finally, to afford individuals' better understanding of subtask procedures, a video was appended to the slideshow. This 5-minute video incorporates a demonstration of the procedures used in each subtask along with an audio description of the processes.

Measurement

The CAPS software enables a smooth transition between training slides, demographic questionnaires, psychological assessments, and the real time interactive simulation that includes all five subjects working together. The CAPS software includes the capability to present participants with questionnaire items to assess various psychological variables. The questionnaire feature generates questions that can be loaded from the experimenter station. In order to enable a generic scenario, an Extensible Markup Language (XML) schema was designed based on an initial set of predictor questions. Figure 3 represents an example extract of the XML scheme devised. (The sample provided represents items taken from the International Personality Item Pool.) Like the chat data, all data from the questionnaires will be logged automatically into a database for analysis.

```
<?xml version="1.0" encoding="utf-8" ?>
<-CAPS_Questionnaire version="1.0" description="Self-report variables of interest for
implementation in the CAPS experimental framework: December 1, 2005">
<-survey name="Background" time="preCAPS">
<-section name="Personality" source="IPIP Scale" instructions="Please rate your
agreement with the following items. There are no correct or incorrect answers, so
don't spend too much time on any one item." order="1">
<-options>
<option order="1">Strongly Disagree</option>
<option order="2">Disagree</option>
<option order="3">Somewhat Disagree</option>
<option order="4">Neither Agree nor Disagree</option>
<option order="5">Somewhat Agree</option>
<option order="6">Agree</option>
<option order="7">Strongly Agree</option>
<-measure name="Extroversion">
<question order="1">I am the life of the party</question>
<question order="6">I do not mind being the center of attention</question>
<question order="16">I typically start conversations</question>
<question order="21">I talk to a lot of different people at parties</question>
</measure>
```

Figure 3. Sample XML Script for the Questionnaire Capability

Individual and group level performance metrics will also be assessed in conjunction with the content rich chat data. A comprehensive task analysis was conducted in order to provide current and future researchers with a deeper understanding of the simulation and its behavioral requirements. In order to identify the inherent performance metrics in the simulation, the task analysis method developed by Berliner and colleagues was used.³⁰ Unlike other task analysis methods, this methodology uses a classification scheme intended to dimensionalize human task behavior in a manner meaningful for measuring performance.³¹ In other words, this method is used to develop a task analysis scheme more amenable to performance measurement and quantification. Moreover, their research efforts were directed at military jobs and man-machine environments, which clearly align with our simulation. The information gained from the task analysis in terms of measurable performance outcomes highlights the research malleability of the simulation and alleviates future researchers' efforts to identify the viability of the simulation for a particular study.

The task analysis multilevel classification scheme is based on a hierarchical model of behaviors, activities and processes.³² The model is composed of four high-level behavioral processes at the apex, which encompass six broad activity categories, followed by several specific behaviors. Beginning at the base of the hierarchy, once a specific behavior is identified, the subsequent activity and behavioral process categories are predetermined. As the intent of the scheme is to aid with performance measurement, the specific behaviors are represented by action verbs which have been validated as simple acts with quantifiable properties as well as easily identifiable and generalizable across jobs. Furthermore, graphical representation in a matrix system permits the identification of explicit links between behavioral variable categories and quantifiable performance measurement dimensions, such as times, errors, and frequency data.³³ Thus, the cells of the matrix contain specific behavioral statements pertinent to performance measurement and evaluation (see Table 1).

From the team level perspective, adaptability is an important dimension of teamwork.³⁴ In an effort to assess the adaptability of the team, a measure was devised comprising the amount of time it took the team to overcome an unexpected event. After the team has had adequate practice time and was able to perform the task, the team was presented with a novel situation. Of particular interest were events that force the collaborative replanning or repurposing of assets controlled by multiple subjects. The team's response to this novel situation was evaluated in terms of chat communications and the objective

Behaviors	Perceptual Processes	Searching for and Receiving Information				
		Identifying Objects, Actions, Events				
	Mediational Processes	Information Processing				
		Problem Solving and Decisionmaking				
	Communication Processes	Communicating				
	Motor Processes	Simple, Discrete				
		Complex, Continuous				
			Time	Accuracy	Frequency	Errors
			Measures			

Table 1. Individual-Based Matrix of Behaviors and Measures (sample)

measure of how fast they were able to overcome the obstacle. The types of distinct challenges that were presented to the subjects included diverted aircraft, maintenance problems, section specific information, communication failures, and altered cargo and passenger requirements. In such situations, the aerial port sections needed to collaborate in order to redirect and reallocate their resources to meet the impending demands of the situation. Upon completion of the entire experiment, all the data were written to an Excel file for easy analysis by researchers because the results were now importable to a variety of statistical software suites.

Research Topics

CAPS will provide a versatile experimental platform through which researchers can examine a variety of social and psychological factors that influence the logistics domain. Examples of potential research topics are examining factors that promote shared situational awareness among team members, manipulating leadership styles to measure the impact on decision selection, identifying variables related to interpersonal trust in distributed teams, and examining the impact of different types of collaborative tools on team performance. (Future studies using CAPS will involve the implementation of various forms of

variables and increasing the internal validity of the research findings. By drawing from the operational nature of aerial port operations, CAPS can mirror logistics activities in a distributed team context and provide a sense of face validity to its users. CAPS can benefit the Air Force by identifying factors that influence team collaboration and performance. These factors can then be used to facilitate the performance of teams within the logistics domain and across the Air Force.

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The CAPS software will allow researchers to study logistics collaboration in controlled settings, thus reducing the impact of extraneous variables and increasing the internal validity of the research findings. By drawing from the operational nature of aerial port operations, CAPS can mirror logistics activities in a distributed team context and provide a sense of face validity to its users.

collaborative tools, such as Voice-Over Internet Protocol and video teleconferencing). CAPS represents the laboratory portion of the program of research in the area of collaborative logistics. Ideally, the field-based portion for the collaborative logistics program of research will identify variables that can be manipulated in the laboratory, thus creating synergy between the field- and laboratory-based programs of research.

Conclusion

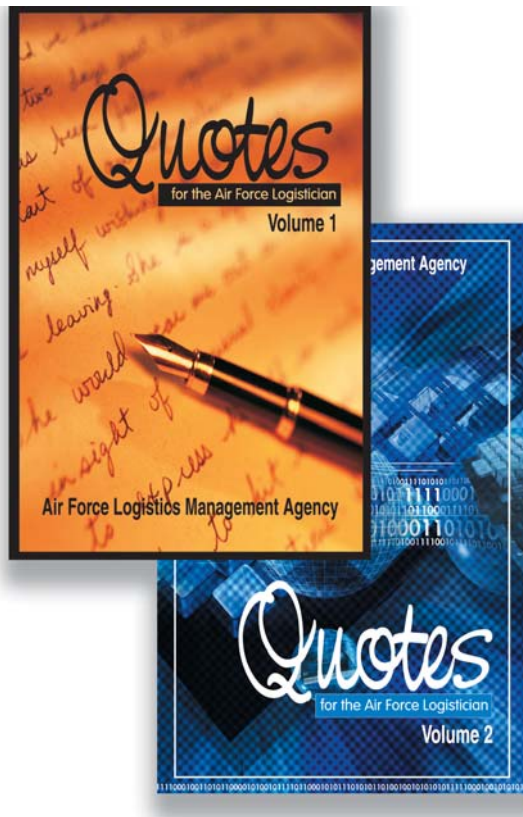
In the information age, collaboration among distributed coworkers will have a significant impact on organizational performance. This is particularly true for the logistics domain which is characterized by distributed information managers interacting across a complex and dynamic problem space. Research in collaboration science will be increasingly important as organizations implement team-based systems. Also important will be the capacity to examine team-based scenarios in laboratory settings to facilitate the manipulation of factors that influence team collaboration and performance. The CAPS software will allow researchers to study logistics collaboration in controlled settings, thus reducing the impact of extraneous

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Meeting the Challenges of the Base Support Installation

Jeffrey C. Bergdolt, Lieutenant Colonel, USAF, AFLMA

Introduction

On October 6, 2008 at 0745, a tremendous explosion rocks a major city within the United States. Many local responders are killed or injured in the initial blast. Every building within a one-mile radius is severely damaged and debris can be found miles away. The streets are inundated with casualties. Responders from surrounding communities quickly assess the situation and call for assistance from the state. The governor realizes the situation will quickly overwhelm state resources, so he requests assistance from the federal government.

The wheels are now in motion for defense support of civil authorities (DSCA). Immediately, US Northern Command (USNORTHCOM) planners and their subordinate commands begin to assess potential base support installations (BSI) to serve as the main logistical hub for military support operations.¹ By 1700 the Secretary of Defense (SECDEF) has declared your base as the BSI for the chemical, biological, radiological, nuclear, and high-yield explosive (CBRNE) Consequence Management Response Force (CCMRF). Within hours your base begins receiving a myriad of DoD units. You are responsible for Joint reception, staging, onward movement and integration (JRSO&I),

and sustainment. Billeting for up to 5,000 troops, hot meals, fuel for helicopters and vehicles all run short, but are essential to mitigating the impact of this catastrophic event. This could happen anywhere in our nation; however, there is concern in the Joint logistics community that base level logisticians are completely unaware that their base is a potential BSI for up to 5,000 CCMRF troops.²

Our national leadership understands that “Despite the best efforts of the United States, our allies, and partners, it is possible that our adversaries might successfully attack our homeland and strategic interests with weapons of mass destruction.”³ In 1996 the Nunn-Lugar-Domenici (NLD) Domestic Preparedness Program (DPP) appointed the DoD to develop a plan for management of a US CBRNE event. In 1999 the DoD established Joint Task Force Civil Support (JTF-CS) under US Joint Forces Command. The objective was to establish an organization dedicated to mitigating the effects of a potential domestic CBRNE incident, complementing traditional homeland defense efforts to deny access to the enemy. In 2002, JTF-CS was transferred to USNORTHCOM.

Today, the JTF-CS mission is to plan and integrate DoD support for domestic CBRNE consequence management operations. To that end, upon direction by the USNORTHCOM Commander, JTF-CS deploys and executes timely and effective command and control of designated Title 10 forces providing DSCA in order to save lives, prevent injury, and provide temporary critical life support. Title 10 forces include DoD active duty and activated Reserve or National Guard troops in federal status. This mission requires considerable logistical planning and, at the point of execution, will depend on significant support from a designated BSI within a reasonable travel distance from the incident area.

In the event of a CBRNE incident, the mission of the JTF-CS is consequence management. The goal is to mitigate the effect of the incident rather than determine the cause, or track down those responsible. However, DoD forces will only be employed when local and state capabilities are overwhelmed and assistance is requested by the governor (see Figure 1).

The magnitude of DoD forces required will vary depending on a number of factors such as local and state resources, density of population, and type of incident. For example, in a large city like Chicago, Illinois, where the population density is

Article Acronyms

BSI – Base Support Installations
CAE – Commander’s Assessment Element
CBRNE – Chemical, Biological, Radiological, Nuclear, and High-Yield Explosive
CCMRF – Consequence Management Response Force
CONUS – Continental United States
DoD – Department of Defense
DSCA – Defense Support of Civil Authorities
IGESP – In Garrison Expeditionary Site Plan
JRSO&I – Joint Reception, Staging, Onward Movement, and Integration
JTF-CS – Joint Task Force Civil Support
MSR – Main Supply Routes
SECDEF – Secretary of Defense
USNORTHCOM – United States Northern Command

approximately 12,000 people per square mile, a CBRNE incident would likely result in heavy casualties. Conversely, in a smaller city like Montgomery, Alabama, where the population density is almost one tenth that of Chicago, the casualties would likely be far less. However, the number of casualties is only one factor in determining the need for DoD forces. While a larger city may experience higher casualties, they may have more resources to deal with the incident, and therefore not require the same level of assistance as a smaller city.

JTF-CS is resourced as a standing command and control headquarters prepared to respond in the event of a CBRNE incident, but with no permanently assigned forces. The required

forces will come from across the DoD and could number in the thousands. A force of that size converging on a community reeling from the effects of a recent CBRNE incident can place an overwhelming demand on already scarce resources. To ensure the force maintains positive momentum in a limited resource environment, the SECDEF will sustain Title 10 forces by designating a BSI. While the BSI will not be under operational control of USNORTHCOM, it will be designated by the Chairman of the Joint Chiefs of Staff execution order as supporting to USNORTHCOM, the supported command. The BSI will provide common-user logistics support (fuel, food, general supplies) and assist a Joint task force with the JRSO&I of responding DoD

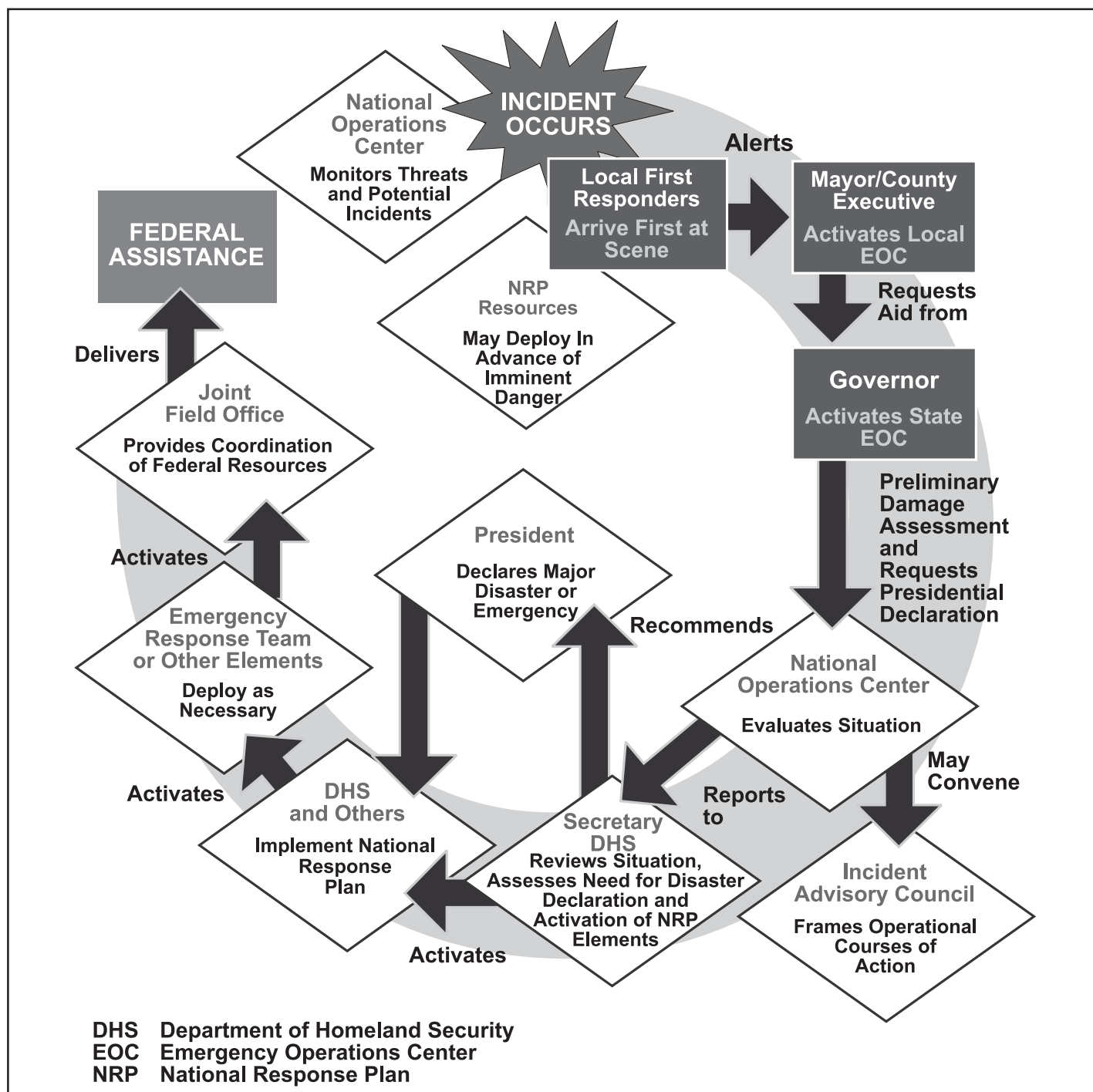


Figure 1. Federal Response, Joint Publication 3-28, Figure D-1

A fully functional CCMRF is approximately 5,000 people, with 900 vehicles and 60 helicopters. The supply planning factors listed are to sustain the CCMRF for up to 30 days.

CCMRF Elements		Quantity	Parking
Personnel		5,000	
Vehicles			
	HMMWV	608	665'x450'
	MTV/LMTV	225	490'x305'
	HEMTT/LHS	64	500'x170'
Aircraft			
Helicopters			1,300'x1,640'
	HH-60	50	
	CH-47	10	

Class of Supply	Subclass	Planning Factors (1 Day)	14-Day Requirement	30-Day Requirement
Class I Subsistence				
	Meals	A-M-A Meal Cycle = 2 Hot Meals per Day	140,000	300,000
	Meals Ready to Eat (MRE)	A-M-A Meal Cycle = 1 MRE per Day	70,000 MRE or 5,834 Cases	150,000 MRE or 12,500 Cases
	Water (potable drinking water)	5 Gallons per Person per Day = 25,000 Gallons per Day	350,000 Gallons	750,000 Gallons
	Ice	3 Pounds per Person per Day = 15,000 Pounds per Day	210,000 Pounds	450,000 Pounds
Class II Clothing, Individual Equipment, Administration Supplies		Unit Basic Load	Unit Basic Load	Unit Basic Load
Class III Petroleum, Oil, and Lubricants				
	Packaged	Unit Bench Stock	Unit Bench Stock	Unit Bench Stock
	Bulk	48,050 Gallons per Day = Total Requirement	672,000 Gallons	1,441,500 Gallons
	Aircraft	60 Aircraft at 250 Hours per Day; 100 gallons per Hour = 25,000 Gallons per Day	350,000 Gallons	750,000 Gallons
Class IV Construction Materials		1,000 ft Concertina Wire; 100 sand bags	1,000 ft Concertina Wire; 100 sand bags	1,000 ft Concertina Wire; 100 sand bags
Class V Ammunition		TBD	TBD	TBD
Class VI Personal Demand Items		Individual Responsibility	Individual Responsibility	Individual Responsibility
Class VII Major End Items, Racks, Pylons, and Others		Equipment Authorized to Accomplish the Mission	Equipment Authorized to Accomplish the Mission	Equipment Authorized to Accomplish the Mission
Class VIII Medical Materials		Unit Responsibility = 30 Days of Supply	Unit Responsibility = 30 Days of Supply	Unit Responsibility = 30 Days of Supply
Class IX Repair Parts		Unit Bench Stock with Reach Back to Services	Unit Bench Stock with Reach Back to Services	Unit Bench Stock with Reach Back to Services
Lodging	Lodging Requirements = 5,000 Beds for the Duration of the Mission. Historically, Females Represent 25 – 30 Percent of the Lodging Requirement			
Operations	Approximately 15,000 Square Feet Required for Operations Centers			

Figure 2. CCMRF, BSI APOD JPG Template

forces. Figure 2 breaks down requirements by class of supply for a full CCMRF response force. For planning purposes, JTF-CS uses the 30-day requirement identified in standard operating procedures. While no individual base can meet all requirements with supplies on hand, deliberate planning will ensure additional sources of supply critical to mission success.

CCMRF Supply Requirements

In addition to the emergency management requirements levied by Air Force policy directive, including force protection, critical infrastructure, and antiterrorism, every DoD installation is a potential BSI.⁴ It is therefore vital for base logistics officers to understand and plan for the reception and sustainment of CBRNE response forces using reasonable planning assumptions. Deliberate planning is important to ensure potential contingency support agreements with local communities are considered in light of potential BSI requirements for supporting up to 5,000 troops. Due to the time-critical nature of DSCA support, the reception and beddown of these troops will require mobilization of existing assets and contingency contracting for everything from potable water to vehicle maintenance. The JTF-CS Contracting Management Cell will serve as the point of contact for the BSI for all contracting requirements.

Upon notification JTF-CS begins an immediate response ready to deploy its first contingent, the commander's assessment element (CAE), within 4 hours. The CAE deploys to the vicinity of a CBRNE incident to gain early situational awareness and conduct assessments in response to a CBRNE situation.⁵ Depending on the assessment of the CAE, JTF-CS may send a forward logistics element to the most likely BSI to validate the availability of capabilities to conduct JRSO&I, aerial port of debarkation, and movement control operations. More specifically, they will assess general supply and maintenance operations; personnel and equipment reception and staging areas; and facilities, civil engineering, health, and other services, to include billeting, food service, contracting, and communications. If augmentation is required, a JTF-CS augmentation team will deploy along with the main JTF-CS body. At the same time, units that make up the CCMRF will deploy from their home stations and converge on the BSI. The BSI may see as many as 5,000 forces arriving, processing, and requiring support within a 24 to 96 hour window following an incident.

All Air Force installations maintain an In Garrison Expeditionary Site Plan (IGESP) that defines the information necessary for making beddown, reception, and deployment-planning decisions. Along with the basic IGESP, additional planning in coordination with JTF-CS may be required to efficiently execute this mission at a time when countless agencies are vying for scarce local resources. However, research indicates logistics officers at CONUS Air Force bases are not aware of the BSI concept; therefore little to no planning has been completed.⁶ This additional planning is a vital piece of the overall National Response Plan to provide the structure and mechanism for

establishing national level policy and operational direction regarding federal support to state and local incident managers.

BSI determination is based on a number of criteria, with base location, airfield capabilities, the communication infrastructure, and main supply routes (MSR) at the top of the list.⁷ Obviously while positioning the headquarters close to the incident may possibly expose forces to radiological fallout in the case of a 10-kiloton nuclear explosion, potential fallout areas would be avoided using plume models and other assessments. In many incidents the airfield capability and capacity will be important for moving response forces, equipment, and supplies into the Joint operations area. Of equal importance to the efficient operation of a BSI is the availability of MSRs, or the availability of surface routes for the bulk of traffic flow in support of military operations. While weighted slightly less in determining a BSI location, there are a number of other considerations such as billeting capacity (barracks, gyms, hangars and such will likely be used for billeting), supply support, and fuel availability. As potential BSI locations are narrowed, the JTF-CS Joint Planning Group will coordinate with logistics officers at candidate bases to obtain any additional information, such as ongoing base construction or repairs, that may impact BSI operations. After a complete analysis, the JTF-CS will recommend a BSI location to USNORTHCOM who will coordinate with SECDEF to make a final designation. This gives the designated BSI little time to prepare for its JRSO&I mission.

Given the countless scenarios, including man-made and accidental CBRNE disasters, every CONUS installation must be prepared to fulfill its potential BSI requirements with little to no notice. This can only be done with significant planning and coordination. As bases continue to develop deliberate plans to support a significant CBRNE response force, JTF-CS stands ready to assist. Start by exploring <http://www.jtfc.northcom.mil/>.

End Notes

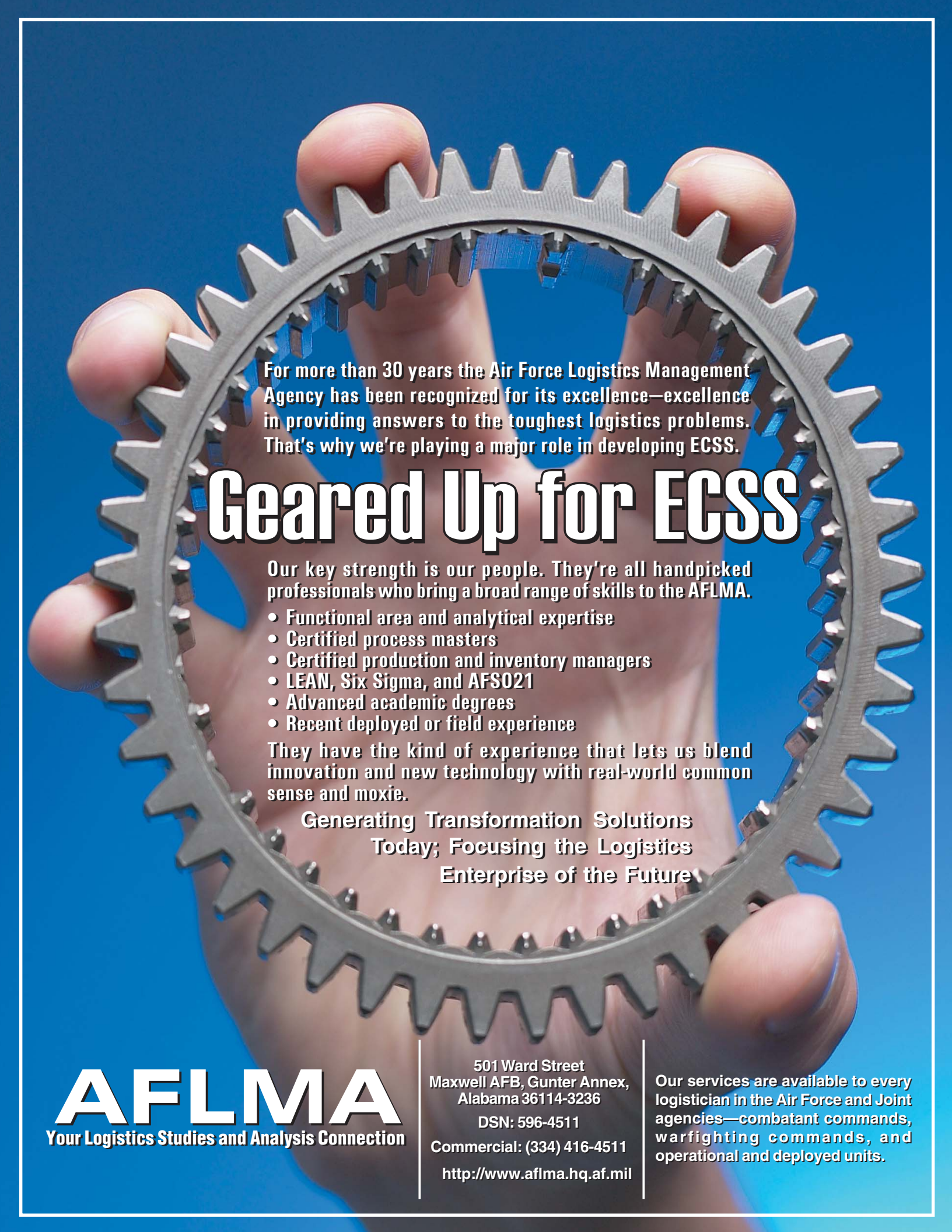
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...instant history [was] invariably shallow history.

—Anthony Cordesman



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